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Jan Sigurd Johnsen

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ABSTRACT

The report shows how various fleet structures, with present raw material supplies, affect employment and the economic situation in a relatively large fishing village. This work is mainly based on data from 1980.

The results show that conventional inshore fishing is 40-50% more labour intensive than trawling or seining. A fleet composed

of inshore fishing vessels is also the most profitable for the fisheries activities of a local community as a whole.

Interim storage of raw material for extended periods becomes very expensive. Whether additional subsidies to achieve a balanced, year-round production are an efficient means of increasing employment, can be determined on the basis of the figures presented in the report.

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3 KEYWORDS

Fleet structure

Profitability

Employment

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FOREWORD

The Research Institute for Fisheries Technology (FTFI)[1] has for several years had on its agenda the intent to analyze the economics of fishing fleets and processing industries, when these two sectors are viewed as an economic unit (Project 644. 1-6).

The importance of analyzing this subject has increased during the last few years, due to the fact that most offshore wet fish trawlers have become clearly unprofitable from the point of view of employment economics, and can only be defended if they have positive effects on employment and profitability ashore. During the last few years, long-term storage of live pollock and re-freezing of cod raw material have become common, as a means of providing a steady supply of raw material to the fish processing plants. All these conditions must be included in a total analysis of the profitability of fishing fleets and processing industries.

The analysis in this report is based on one of these processing industries and the permanent fleet that serves it. The trawlers are owned by the industry, but the rest of the fleet is legally independent of the industry. An alternative approach would have

[1] Transl. note: FTFI = Fiskeriteknologisk Forskningsinstitutt

been to analyze a fishing village and its fleet, or, for example, a municipality with its fish processing plants and vessels. The only problem with this approach is that the somewhat temporary legal form of ownership that exists cannot serve as an adequate framework for the analysis.

The report is a continuation of Jan Sigurd Johnsen's graduate thesis at the Institute for Fisheries, University of Tromsø. The hope is that this report will contribute to a sober debate, with the eye on the future, on some of the crucial problems of the Norwegian fisheries industry.

I extend my thanks to all who have contributed with information and assistance in the development of this report.

Terje Vassdal Group Leader

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SUMMARY

With varying resource conditions, most industries often require different types of efforts, in order to achieve the best possible productive results, both from a technical and an economical viewpoint. In due time, a requirement for a certain level of employment has also been added. These factors seem particularly important to the Norwegian fishing industry in a time with low catch potential.

Based on these factors, a model was produced in this analysis, where the goal was to achieve the highest possible marginal revenue for both fleet and processing industry as one unit. The production costs of the industry are considered as fixed, while the fleet structure and the costs of fishing are considered variable elements. The fish processing data was obtained from a frozen-fish industry in North Norway, and the information about the actual fishing activities was obtained from the Fisheries Directorate.

In order to calculate and compare the employment intensity in the fleet, we used a reference income of 80.000 Nkr[1] per year of operation. According to this, the NET group of vessels are

[1] Transl. note: Nkr = Norwegian crowns (kroner)

40-50% more labour intensive than SEINE and TRAWL. The inshore fleet (NET, SEINE) also shows relatively low fishing costs compared to trawling. With the SEINE group as the basis for comparsion, NET has 27% and TRAWL has 92% higher total fishing costs per kg of raw material than NET. According to our group division, this means that only the offshore trawlers operate with a loss.

Long-term storage of pollock and re-freezing are presently used as a means to achieve a balanced year-round production. However, interim storage leads to high additional costs for an industry that in the past has shown low profitability (Olsen, etc., 1981). Whether this type of storage can be recommended will depend on the particular conditions, such as normal supplies of raw material and additional investments. Calculations based on our data show that long-term storage is somewhat more costly than re-freezing. With a subsidy of 1 Nkr per kg, long-term storage of pollock means a cost increase of 1.25 Nkr per kg. Of this amount, about 0.15 Nkr will be recuperated in the form of a more economically correct product mix.

Total financial results and employment figures were calculated for 5 different production strategies. Because of "low" fishing costs, and in spite of large seasonal fluctuations, a fishing fleet consisting only of inshore fishing vessels gives the best total results. The present fleet structure, which also includes

offshore trawlers, produces an operating surplus that is only about half of what an inshore fleet structure produces. With the resource situation that exists today for our most important fish species, it is, therefore, the inshore fleet that is most suitable from the view-point of economics and labour intensivity.

If the trawlers are scrapped (or sold) and are not replaced by inshore fishing vessels, the operating results will be negative for the fisheries activities in the local community. This is mainly due to the large business loss resulting from a smaller production volume.

An inshore fleet structure which is combined with measures to achieve a balanced, year-round production will still give much better operating results than today's fleet structure, where the offshore trawlers are included.

1 INTRODUCTION

1.1. Introduction - defining the problem

The profitability of the Norwegian fisheries industry has decreased steadily since the basic agreement between the Norwegian Government and the Norwegian Fishermen's Association came into force in 1964. The annual transfers to the fishing industry go a long way to illustrate the problems that different sectors of this industry are having in trying to meet the requirement of profitable operations.

As shown in Figure 1, the subsidy allocated remained around 200 million Nkr during the first 10 years after 1964. From 1974 and in the following 3 years, the transfers were about 500 million Nkr/year, while in 1979 they jumped to 800 million Nkr. The increase in 1980 was even greater, and the subsidy reached its hitherto highest figure of 1.4 billion Nkr. This year (1981) the fisheries agreement amounts to nearly 1.2 billion Nkr.

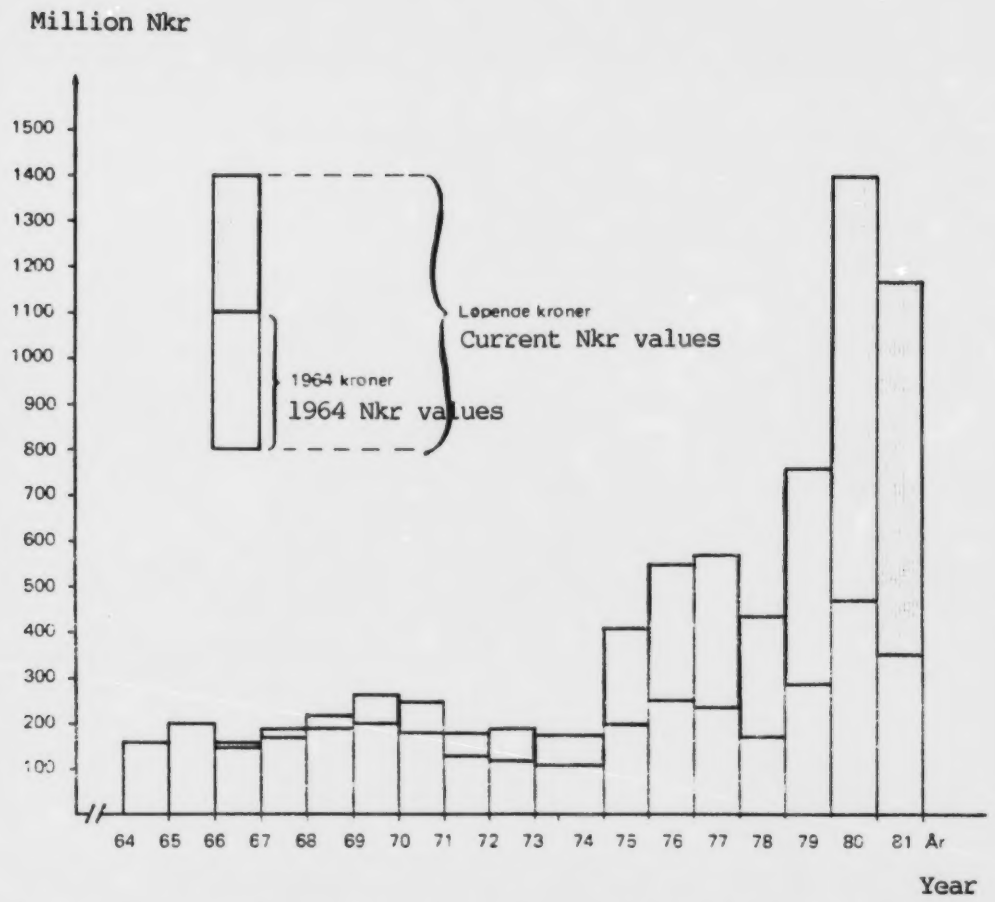

Figure 1. Annual amounts in excess of the fisheries agreement between the Government and the Norwegian Fishermen's Association during the period 1964-81, measured at current value of the krone and at the 1964 value of the krone, deflated with the consumer price index. Source: The Department of Fisheries.

The concept of profitability used during the negotiations is defined as total income less total expenses, including calculated depreciation, interest on borrowed capital and estimated interest on shareholders' equity. Brochmann (1980) describes the economic

situation for the Norwegian fishing industry in 1980 as follows:

The value of business activities in 1980 is expected to be around 5 billion Nkr. Total expenses for the fishing sector, excluding wages, is estimated to be around 2.5 billion Nkr. The expenses within the fish processing industry, excluding wages and raw fish, and in the marketing organisations are set at about 2 billion Nkr. As can be seen, there will be 0.5 billion Nkr left to distribute among the work force in fishing and processing jobs, which will give about 17,000 Nkr per man and year worked assuming that there are a total of 30,000 man working years within the industry.

Of the total basic agreement for 1980 of 1.4 billion Nkr, 0.3 billion Nkr were "earmarked" for structural measures within the industry. If we assume that the remaining 1.1 billion Nkr were transfers to the work force, the income from fishing and processing rises to about 54,000 Nkr per man per working year. On the basis of these rough calculations, government subsidies constitute 70% of the income from work in the sectors of fishing and processing.

The financially extremely difficult situation that is experienced close at hand and daily by those involved in the industry, is, as a result of the subsidies, only "the tip of the iceberg". The

total economy of the industry is, as described above, far more strained.

In the presence of particularly difficult economic conditions, there will be a crystallization of "good" or "bad" operating units, by business standards, regardless of what type of industry or sector we are dealing with.

How well the individual units manage to adapt depends in most cases on the cost structure that exisists for those active in the industry and not least on the actual fishing efficiency (income). In the present resource situation, is a particular type of fleet more profitable and for that reason more adaptable than another, provided that the vessels in each group are identical with regard to efficiency? What are the costs of the raw material that is landed by the different types of vessels?

With the creation of offshore fishing companies and the procurement of wet fish trawlers, vertical integration was introduced in earnest in the Norwegian fisheries industry. From a business economical viewpoint, the investments in these trawlers did not meet expectations, but with good intentions shown by those granting credit to the offshore fishing companies (mainly the National Fishermen's Bank (Statens Fiskarbank)) and the regular "liquidity loans" from the parent company, it has been possible to keep offshore trawling operations going. This type of opera-

tion can, judged by industrial profitability criteria, only go on as long as the results for trawlers and processing plants show a surplus when seen as a whole. A number of offshore fishing companies show a deficit so large that it cannot be covered by the processing sector. Based on the material in "Studies of Fishing Industry Operations", Olsen (1981) has analyzed the relationship between profitability and company-owned trawlers for the businesses included in the study (the results of the actual trawler operations were left aside). The conclusion was that trawler deliveries were previously (up to 1977) a strength for the fish processing plants, while no such relationship can be seen today.

There are many indications that inshore fishing vessels are more profitable than offshore trawlers (Cf. The Profitability Study (LU)[1] 1978, 79). A vertical integration on the local level where the inshore fishing vessels are included in the company should therefore produce better total results, than what is the case with offshore trawlers integrated in the fishing sector. It therefore seems strange that businesses do not invest to a greater extent in this kind of fleet structure. If the adjustment between the fleet and the rest of the company is analyzed for one location, as in this report, it is possible to calculate the total economic results for the fishery in this location. What is

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[1] Transl. note: LU = Lønnsamhetsundersøkelsen

the present economic situation, and what results can be expected with an alternative fleet structure?

As a means of achieving a balanced, year-round production in the fishing industry, long-term storage of pollock and re-freezing have been used. Long-term storage of pollock has introduced a considerable risk element with respect to recovering the fish, while the quality of the raw material has been the drawback of re-freezing. Both of these elements have lead to unreasonably high cost increases for this raw material, and whether the production is profitable is in many cases questionable. For this reason, we have included in this analysis calculations that show the effects of waste percentage and storage costs on the total cost increases for this raw material. The same approach was used for re-freezing, where the yield percentage and the capacity utilization of the re-freezing facility vary. In both cases, the regular price of the raw material was used as the point of departure.

The "new" long-term plan will, according to information from the Department, have a clear profitability profile. This approach is necessary in order to reach the overall objective and satisfy the general requirements for secure and satisfactory work places in the fisheries industry. A structural change will therefore be necessary, both in the fleet sector and in the processing sector, in order to reach the goal of improved profitability. At the same

time, employment within the industry should not be reduced to any considerable extent. This requirement is particularly strong in those coastal districts where there are few or no other employment opportunities. Regions that have a greater variety of alternative work places, should copy with most of the reduction in employment, when such a reduction becomes necessary. The structural change should in any case be completely controlled by the authorities. Each county, region or municipality should therefore ascertain which structure will give them the best results from the viewpoint of economics and employment, and which will not be contrary to the Government's objectives for the fisheries when seen on the macro-level. Such planning necessitates the use of tools that will enable the fisheries administrations on the local level (Fisheries Chief, Fisheries Director) to develop their plans in an efficient and satisfactory manner.

This analysis is in a way divided into two parts, since there is first a cost analysis done on fleet and plant. Towards the end, the introductory calculations are entered into a mathematical model that gives the answers for optimum short-term fleet structure and optimum product mix for the plant, when the objective is maximum marginal revenue for fleet and plant.

1.2. Data basis

The basis was a specific fish processing industry involved in fillet production, where about 60% of the fillet quantity also goes through further processing. Although this industry has its own offshore trawlers, it is constantly battling an extremely seasonal supply of raw material. According to "Studies of Fishing Industry Operations" (Norwegian Fish Producers' Association - NFF), this company must be characterized as a large freezing plant, and their purchases of raw material were in 1979 5.3 million kg and in 1980, 3.8 million kg. In spite of these large quantities, the annual financial accounts showed a loss in both years.

Besides the company's 3 offshore wet fish trawlers, the fleet also includes some small fishing boats and some medium-sized vessels. To this are added the pollock purse seiners that are subject to re-direction orders and for this reason cannot be said to "belong" in any particular place. During special seasons, a large number of foreign boats also deliver to the plant.

Because much of the data is confidential, I have taken the precaution of calling the company A/S FISH PROCESSING, and the place where it is located was given the name SØRFJORD. The offshore fishing company and its trawlers will here be called OFFSHORE FISHING.

The business data was provided by A/S Fish Processing. Operating expense figures for the inshore fleet and the trawlers were taken from "Profitability studies of fishing vessels larger than 40 feet (1980)", produced annually by the Budget Committee of the fisheries industry. The figures for long-term storage of pollock were taken from The Agency for Co-operative Development of the Fisheries in Finnmark County (OUF)[1], the cost figures for re-freezing were kindly made available by A/S Melbu Fiskeindustry (Melbu Fishery Industry, Inc.) and the National Norwegian Institute of Technology (STI)[2]. However, some of the last mentioned cost figures are somewhat out-dated, so that it was necessary to make some adjustments.

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[1] Transl. note: OUF = Organ for Utviklingssamarbeid i Fiskeindustrien i Finnmark.

[2] Transl. note: STI = Statens Teknologiske Institutt

2. GENERAL DESCRIPTION - THE PLANT AND ITS FLEET

2.1. The plant

A/S Fish Processing is one of the companies in a corporation that operates a number of fish processing industries along the coast. The plants are of varying size and have different types of production. All the plants in the corporation are members of the marketing chain (sales organisation) FRIONOR.

A/S Fish Processing has about 150 employees, but the numbers may vary somewhat with the season (raw material supply). The plant employs between 40 and 50% of all the fisheries employees in the municipality, and it is also the largest work place in the municipality (Samuelsen, 1977). Consequently, large fluctuations in the fishing sector (the basic occupation) and thereby in the employment at A/S Fish Processing, have serious consequences for all other activities in Sørfjord.

2.1.1. Business development 1970-1981

According to the annual financial reports, the fillet production has remained relatively steady at an average of about 2,400 t fillets per year. The quantity varies from 1.8 to 2.8 million kg, but the operating results for the period show greater fluctuations. From Figure 2 we can draw the conclusion that the produced

quantities were not of decisive importance to the operating results. Thus, it was external effects that contributed to the varied operating results. The 1975 loss can be directly attributed to the market conditions that existed for frozen fish in that year. Product development costs in 1978 and 1979 have also clearly affected the results.

Since the annual reports do not contain quantity figures for the production of other products besides fillets, it was not possible to find the total quantity of purchased raw material for all the years. The quantity of conventional products would probably have shown greater variations, but since the use of fillets accounted for a bit more than 90% of the total, it would not have had a noticeable effect on the changes in total quantity.

With the start of a new decade, the raw material policy of A/S Fish Processing was radically changed. Two new stern trawlers were purchased. Before this time, the company had contracts with privately owned trawlers that delivered more or less steadily to the plant. The creation of Offshore Fishing and the procurement of the two first offshore wet fish trawlers soon proved to be a success - during the first years of operation. After the first year of operation of these vessels, the statement of income and expenditure in the annual financial report for 1970 was presented with the following comments:

"The statement shows that an industrial fish plant cannot be operated at the mentioned localities without trawlers, since these are of crucial importance to a balanced, year-round operation, a stable work force and the society as a whole."

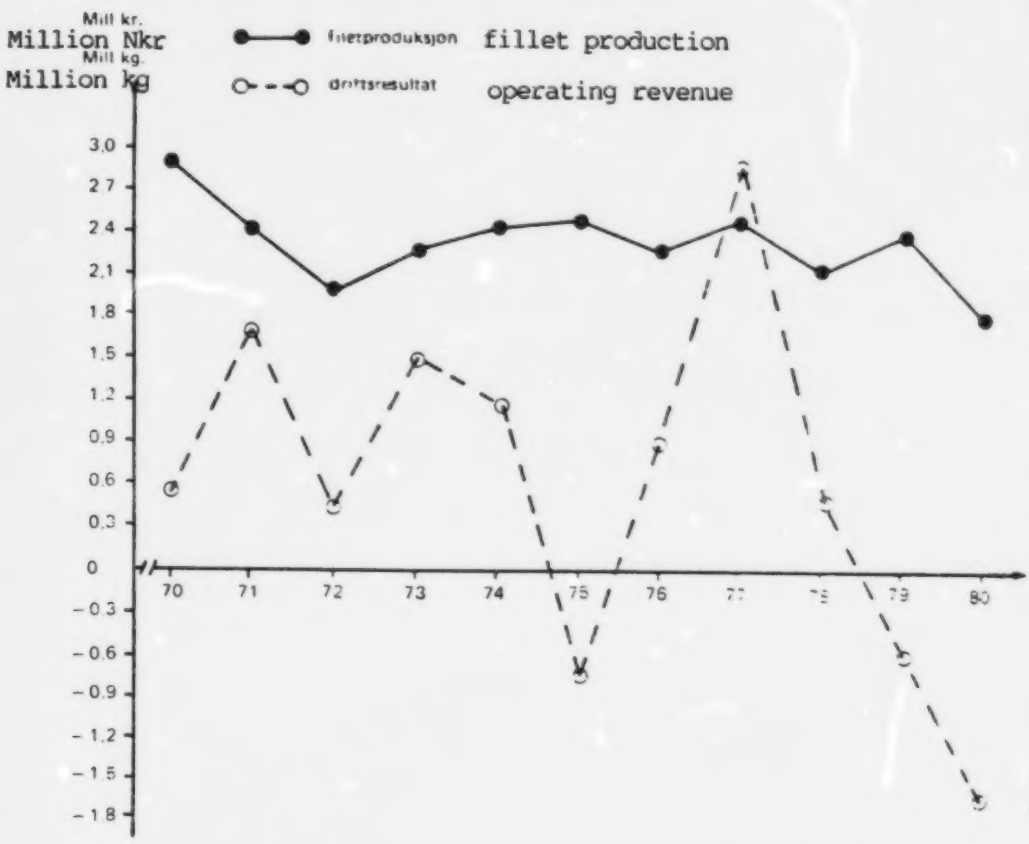

Figure 2: Fillet production and operating results for A/S Fish Processing for 1970 - 1980.

However, it soon turned out that the overwhelming optimism regarding these vessels would to have to be modified. Already in 1971 (the year after they were bought) we can read in the annual

report of the offshore fishing companies in which the corporation has shares, the following:

> "The operating income of the offshore fishing companies does not in all cases cover full depreciation. But the activities at sea and ashore must be seen as a whole, and thus the trawlers have contributed to a large extent to the total results."

The idea about vertical integration appears gradually to have come to the forefront. Even if the production of one "department" results in a loss, it will produce a total surplus, and a contract for a third offshore fresh fish trawler was signed and the vessel was delivered in 1973.

The somewhat weak operating income from the trawlers in 1971 appeared to be of a temporary nature, and Offshore Fishing showed a surplus after full depreciations up to 1976. From this year on, the loss from the trawler operations only increased year by year. The quota regulations for Norwegian-Arctic cod were the first limitation that led to poorer operating results. Later on, the fuel costs also increased so that profitable operation appears unrealistic. This is because the bunker costs constitute 25-30% of the total operating costs (Offshore Fishing, 1979).

2.1.2. Departments, capacity and product aspects

A/S Fish Processing has three major production departments: the wharf, fillet, and finished product departments. These departments are more or less dependent on each other in their production.

2.1.2.1. The wharf department

The department employs about 15 individuals, all men. The work in this department consists of receiving the raw materials, the production of salted fish, dried fish, animal fodder, fish oil, and the packing of fish to be used fresh. The reception work consists of unloading, weighing a 10% sample, and clearing the trawlers, the weighing and icing of fish from the inshore fleet, and the gutting of pollock when in season. The different work operations are paid at different rates (piece work). During the slow season, there is a regular hourly pay (as is also the case during slow periods).

It is not relevant to determine capacity, since the "wharf work" is not a limiting factor in the production of fillets. The main production is the production of fillets, so that conventional products are only produced when the capacity limit has been reached in the fillet department, or when the quality of the raw material does not permit it to be used fillets.

2.1.2.2. The fillet department

When capacity is fully utilized, 72 individuals work in the department, whereof 45 are women. Cutting and skinning functions are performed by machines. Filleting, weighing, packing and operating the freezers are done manually. The fillet department produces mainly blocks of 22.5 kg each. In 1979, the production of blocks constituted more than 91% of the total quantity of fillets, which was more than 2,383 t. Consumer packages of 5 lbs accounted for about 7% and the remaining quantity consisted of catering products of 4.5 kg each.

However, in the autumn of 1981, a new fillet line (group table) was installed which made the production in the fillet department more flexible.

For fish weighing between 1.5 and 2 kg, the maximum capacity of the fillet department for block production is 30 t raw fish per day (8 hours), on the condition that the work force is not a limiting factor. The corresponding capacity for production of consumer packages is 15 t. These capacities are the actual limits for fillet production in the plant as a whole (see also Section 5.2).

The wages consist of an 80% fixed portion and a 20% bonus portion per hour. This form of payment does not "reward" particularly fast fillet workers to the extent pure piece work does. Thus, such a wage form ought to produce a better working environment (less stress).

2.1.2.3. The finished product department

The entire production of this department is based on blocks of pollock and cod as raw material. Should the plant not have any blocks in stock, transfers within the corporation would then be made. This means that production in the finished product department is "never" interrupted because of a lack of raw material. In 1979, the department produced around 1,500 t. New technical equipment was installed in 1980 and the daily capacity is estimated to increase from 8 to 10 t finished products. The produced quantity thus increased in 1980 to more than 2,000 t.

A little more than 20 individuals are employed in this department, and the wage system is based on a 100% fixed hourly pay.

The products made here are fish fingers, and portion packs. These products are equally labour intensive and the daily capacity is therefore the same for both.

2.1.3. Separation into catch and production periods

The time unit on which the separation into periods is based, is 4 weeks (of 7 days each). These means 13 basic periods, which are further divided into 4 main periods (catch/production periods) in order to simplify the model. The time is calculated from the 1st of January. Four weeks of general vacation are set aside in 3 periods, and otherwise Saturdays, Sundays and other holidays have been deducted in order to arrive at the number of effective working days.

1st period	12 weeks	50 working days
2nd "	16 "	74 "
3rd "	12 "	40 "
4th "	12 "	57 "
TOTAL	52 weeks	230 working days

The actual capacity limits for each period were calculated on the basis of the number of 8 hour working days and the daily capacity. Due to these factors, the arithmetic average cannot be used for comparing the raw material supplies and employment of one period to another. In order to do this, we must introduce the concepts of raw material supply and employment per day of production. These concepts will here be represented by values in per cent of utilized capacity.

The separation into periods will also apply to the catch sector.

2.1.4. Raw material costs - product cost estimates

In order to simplify the analysis, we will work with 2 kinds of fish that can be used for fillets or for salting. Since cod, haddock and pollock constitute the major part of the total quantity (92% in 1980 for price zones 1-6 of the Norwegian Raw Fish Association (NR)[1] district) we will, for production and marketing reasons (better price for cod and haddock than for pollock), make the following division: cod/haddock as one type of fish and pollock as the second type of fish.

The raw material prices (including subsidies) are determined by the Norwegian Raw Fish Association and the prices used apply to the period from Oct 15 - Dec 31, 1981 (they were changed later during the autumn). Due to our division into fish types, it is assumed that 81% of the quantity of cod/haddock is cod and that the remaining 19% is pollock. With respect to size, it is assumed that the average size of cod/haddock is between 45 and 60 cm, and pollock from 45 to 55 cm. Based on these prerequisites, the raw material costs and fish prices will be primarily as listed below.

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[1] Transl. note: NR = Norges Rafisklag

Table 1: Minimum prices and subsidies per kg, Autumn 1981.

	Cod/haddock		Pollock	
	Freezing	Salting	Freezing	Salting
Price to fishermen	4.80	5.02	3.20	2.50
Subsidy	1.43	0.35	1.18	0.88
Net raw fish price	3.37	4.67	2.02	1.62

It is assumed that the fillet products can be made into 22.5 kg blocks and 5 lbs consumer packages. For calculation purposes, salted fish made from cod/haddock will consist 100% of cod. Salted pollock will, besides regular split fish, also consist of so-called back-bone pollock.[1] The sales prices (invoice prices) vary somewhat, but according to the 1980 annual report of the Fish Producers' Marketing Cooperative A/L (FF)[2] and this organisation's budget for 1981, the prices were set as shown below. The somewhat low invoice price for salted pollock is the result of a relatively low price for back-bone pollock.

Other production cost figures were provided by A/S Fish Processing

[1] Transl. note: Split and salted pollock with intact backbone.

[2] Transl. note: FF = Fiskeprodusentenes Fellessalg

Table 2: Cost estimates for fillet products. Nkr per kg finished product.

Product	22.5 kg block		5 lbs consumer package	
Fish species	Pollock	Cod/haddock	Pollock	Cod/haddock
Yield percentage	56	52	55	51
Sales price	7.98	11.28	9.95	13.38
Raw material	3.61	6.48	3.67	6.61
Packing	0.16	0.16	0.55	0.55
Wages	2.35	2.45	3.29	3.50
Total product cost	6.12	9.09	7.51	10.66
Marginal revenue I	1.86	2.19	2.44	2.72
Marginal revenue, by-products	0.40	0.68	0.40	0.68
Marginal revenue II	2.26	2.87	2.84	3.40

Marginal revenue for Friochip[1] is set at 4.32/kg

" " " minced fish " " " 3.29/kg

" " " animal feed " " " 0.56/kg

The marginal revenue from by-products per kg of fillet is arrived at in the following manner (cod/haddock is the example used).

[1] Transl. note: Norwegian "friochip" probably refers to frozen fish flakes. Unconfirmed.

Table 3: By-products

	Yield %	Marginal revenue
Fillet	51 %	2.72 Nkr
By-products		
- fish flakes 6 %		0.26 "
- minced fish 6 %		0.20 "
- animal feed 37 %	49 %	0.22 "
Gutted, head-off fish	100 %	3.40 Nkr

The yield for fish used for salting was 58% of gutted, head-off weight, according to the company.

Table 4: Cost estimates for salted fish (Nkr per kg finished product).

Fish species	Cod		Pollock	
Sales price	10.00		4.40	
Raw material		8.05		2.79
Packing/salt		0.09		0.09
Direct wages		0.89		1.00
Total product cost	9.03		3.88	
Marginal revenue	0.97		0.52	

2.2. The fleet

The fishing fleet is divided into 3 groups of vessels. With minor changes this division is identical to the vessel groups designated 001, 010 and 027 in the Profitability Study (LU). Two of the groups must be characterized as typical inshore fishing vessels, while the third consists of the processing company's offshore wet fish trawlers. As within traditional fisheries economics, it is assumed that all vessels within each group are identical and equally efficient.

In the catch sector, a different concept will be used with respect to work remuneration. For each type of fleet, average costs per kg of raw material landed will be calculated. In the continued analysis, the reference income will be set at 80,000 Nkr per year. This figure was not chosen because the opportunities for an alternative income in fishing are actually at such a high level, but mostly because it is difficult to recruit crews when the income offered is below this level.

2.2.1. Cost distribution.

In the following, the costs for the fishing sector will be divided into three components: <u>catch dependent variables, non-catch dependent variables and fixed costs.</u> Problems will arise when it comes to dividing the vessel maintenance costs into fixed

and variable costs. What portion of the maintenance costs should be considered as fixed costs, could be discussed in each case (type of vessel). Hansen and Lensberg (1980) refer to the Profitability Study (LU) and the Fisheries Directorate, and have used the following cost allocation key for the fixed portion of the maintenance costs:

20 - 40'	54%
40 - 60'	55%
60 - 70'	58%
70 - 120'	67%
Stern trawlers	66%

It may seem as though this cost allocation method results in too high maintenance costs, but we still chose to use this key, since there is no other cost allocation method available. The percentages for fixed (F) and variable (V) maintenance for the types of vessels in question will then be as follows:

GARN	NET	F/V	55/45%	GILLNET
NOT	SEINE	F/V	58/42%	
TRAAL	TRAWL	F/V	66/34%	

Catch dependent variable costs are presumed to be proportional to the catch quantity, while the non-catch dependent variable costs are presumed to be proportional to the operating time.

Catch dependent variable costs: Product/NR[1] dues
Telephone/harbour dues
Wages to crew
Social costs
Hired temporary labour
Miscellaneous

The product and Raw Fish Association dues are in reality a tax. This item is also included here, since it was listed by the Profitability Study (LU) as an operating expense.

Non-catch dependent variable costs: Fishing gear maintenance
Vessel maintenance
Oil/bunkers
Bait/salt

Due to fluctuations in the availability of fish during the year and thus also in the catch, as well as a varying number of effective operating days in each period, the variable costs (and the marginal revenue) will fluctuate during the year. The number of operating days (24 hour) in the periods are recorded as being about the same as the number of production days in each period.

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[1] Transl. note: NR = Norwegian Raw Fish Association

2.2.2. Net, longline (GILLNET (GARN), HANDLINE (JUKSA) AND DANISH SEINE) and Danish seine by the coast and on the banks (GILL-NET)

From here on this group will be called NET, and it consists of 13-20 meter (40-69 feet) long vessels with an average operating time of 275 days (24 hour), whereof 160 days at sea. The size of the crews vary, but the average is 3.7 men on each boat.

A rough division of their catch in 1978 (The Profitability Study (LU)) showed that about 7% consisted of pollock, cod and haddock together amounted to 90%, while 3% consisted of other fish. It is assumed that this division is the same for 1980 when the average annual catch per vessel was 207 t.

The vessels in this group are not involved in fishing that is regulated by quotas, and it is reasonable to assume that the average annual catch for coming years will remain at this level.

There are still large seasonal variations for this group of vessels. This is the result of both fish availability (biological and oceanographical conditions) and weather conditions. This fleet is more dependent on good weather than the large oceangoing fishing fleet. Based on the size of the vessels and their operating methods, their landings of raw material during the year are more or less given.

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Table 5: Statement of expenses for the NET group of vessels, excluding wages to the crews.

	Nkr
Fuel	43,605.5
Bait, ice, salt, etc.	2,869.3
Hired temporary labour	18,575.9
Telephone, harbour dues	3,209.7
Social expenses	1,417.8
Product dues	20,645.0
Miscellaneous insurance	2,168.2
Misc. unspecified expenses	5,194.1
Fishing gear insurance	237.5
Fishing gear maintenance	54,760.2
Depreciation on fishing gear	816.2
Vessel insurance	9,261.6
Vessel maintenance	41,843.7
Depreciation on vessels (estimated)	74,112.2
Loan interest payments	25,483.5
Estimated interest on shareholders' equity	39,053.5
TOTAL EXPENSES	343,254.

Depreciation on vessels is estimated (based on the replacement value).

Table 6: Average total expenses per kg of raw material as a function of a reference income (NET).

Reference income	Mean cost per kg
50,000 (185)	2.55
60,000 (222)	2.73
70,000 (259)	2.91
80,000 (296)	3.09
90,000 (333)	3.27
100,000 (370)	3.45

Figures in brackets are total wages/salaries in 1000 Nkr.

The expenses distributed according to the applied cost allocation key give the variable operating expenses per catch period as shown in Table 6. The marginal revenue per kg can be determined for each period using a given, total price paid to the fishermen.

Table 7: Variable fishing expenses per vessel for NET, divided into periods.

Catch period	1	2	3	4
Catch dependent variables	77,212	139,948	77,212	50,671
Non-catch dependent variables	30,799	038,629	20,881	29,755
Variable catch expenses	108,011	178,577	98,093	80,426
Variable expenses/kg	2.33	2.13	2.12	2.65
Mean variable expenses per kg for the year				2.25

2.2.3. Seining off North Norway (SEINE) (NOT)

The operating data for this type of fleet were also obtained from the Profitability Study (LU) for 1980. According to the study, the size of the vessels is 13 meters (40 feet) or longer. The average length of the 17 vessels included in this selection was 21 meter, and the average number of operating days (24 hour) was 263. The size of the crew varied with the size of the vessel, but the mean was 6.9 men per vessel.

This group of vessels was originally (010 in the Profitability Study (LU)) listed as having the following average pattern of operations in 1978: 61% seine, 25% net, 5% floater trawl and 5% Danish seine. Floater trawl here refers to capelin trawl. Since this report discusses problems with the supply of raw material within the cod fisheries, capelin trawling was "eliminated" from the pattern of operations of these vessels. Furthermore, the time alloted to seining appears to be too low. Based on data for the operating pattern of seiners in the area of Sørfjord, it is assumed that this type of vessel has the following operating time pattern:

75% seine

25% net

Net fishing takes place during the months of January, February, and March. The rest of the year is taken up by seining. This group of vessels is also not involved in quota regulated fishing, and the same operating limitations apply to this type of operation as for the NET group of vessels (weather and availability of fish). Seining (combined with netting) is an extremely seasonal fishery, as is that of the NET group of vessels. The peak season for pollock is June-September, but also the time just before and after can be useful months for the pollock purse seiners.

The average catch per vessel in 1980 was 565 t for the SEINE

The average catch per vessel in 1980 was 565 t for the SEINE group, where it is assumed that 75% of the quantity consisted of pollock. The remaining 25% were mainly cod and haddock.

Table 8: Statement of expenses for the SEINE group of vessels, excluding wages to the crews.

Expense item	Nkr.
Fuel	99,409.5
Bait, ice, salt, etc.	2,550.9
Hired temporary labour	5,848.2
Telephone, harbour dues, etc.	12,350.8
Social expenses	2,401.2
Product dues	30,470.4
Miscellaneous insurance	2,923.2
Misc. unspecified expenses	12,510.8
Fishing gear insurance	3,254.6
Fishing gear maintenance	82,475.6
Depreciation on fishing gear	46,316.5
Vessel insurance	25,167.9
Vessel maintenance	122,943.8
Depreciation on vessels (estimated)	207,260.0
Loan interest payments	58,221.1
Estimated interest on shareholders' equity	107,995.9
TOTAL EXPENSES	822,100.3

Vessel depreciation is according to calculations.

With a given catch quantity and given operating expenses, excluding wages, but with a varied reference income, the calculations can be summarized as shown in Table 9.

Table 9: Total expenses per kg of raw material landed by the SEINE group of vessels, as a function of a reference income.

Reference income	Average expenses per kg
50,000 (345)	2.07
60,000 (414)	2.19
70,000 (483)	2.31
80,000 (552)	2.43
90,000 (621)	2.55
100,000 (690)	2.67

Figures in brackets represent total wage expenses in 1000 Nkr.

With an income of 80,000 Nkr per year, divided according to the prerequisites, the variable expenses per period will be distributed as shown in Table 10.

Table 10: Variable catch expenses per vessel for SEINE group, divided into fishing periods.

Catch period	1	2	3	4
Catch dependent variables	98,552	164,007	279,476	73,546
Non-catch dependent "	60,558	75,954	41,056	58,505
Variable catch expenses	159,110	239,961	320,532	132,051
Variable expenses per kg	1.76	1.59	1.25	1.96

The average variable expenses during the year would then be around 1.51 Nkr per kg of landed raw material by the SEINE group of vessels.

2.2.4. Offshore wet fish trawlers (TRAWL)

A/S Fish Processing has a controlling interest in its subsidiary Offshore Fishing, which owns 3 offshore wet fish trawlers. The raw material deliveries from the offshore trawlers have been relatively more regular than from the inshore fleet. This, of course, has to do with the operating radius of the vessels. Nevertheless, the trawlers (perhaps the trawlers in particular) have also noticed a decline in catch potential, and the landings of this group of vessels has become more seasonal. In 1981, the regular quota of these 3 offshore trawlers was 2,505 t of cod and haddock. There was also an extra 17% quota for haddock. Based on these figures, it is assumed that Offshore Fishing will deliver 2,730 t, including other species apart from cod and haddock, to A/S Fish Processing.

In order to have identical data for the entire fleet sector, the economic data for this group of vessels was also taken from the Profitability Study of 1980. This gives the average catch per year as 1,146 t. The gross register tonnage of the vessels was 200 and above, and the operating days (24 hour) were 190, whereof 148 were at sea. The average size of the crews was 13.4 men.

Table 11: Statement of expenses for TRAWL, excluding wages to the crews.

Expense item	Nkr
Fuel	1,032,331.0
Bait, ice, salt, etc.	4,667.4
Hired temporary labour	22,660.5
Telephone, harbour dues, etc.	128,564.1
Social expenses	19,471.8
Product dues	141,661.3
Miscellaneous insurance	16,250.8
Misc. unspecified expenses	98,173.2
Fishing gear insurance	0.0
Fishing gear maintenance	0.0
Depreciation on fishing gear	436,828.1
Vessel insurance	143,428.5
Vessel maintenance	502,828.4
Depreciation on vessels (estimated)	905,673.9
Loan interest payments	402,964.6
Estimated interest on shareholders' equity	473,560.2
TOTAL EXPENSES	4,293,063.7

Depreciation on vessels is according to calculations.

Wages are considered as a fully catch dependent variable expense for NET and SEINE (the inshore fleet). The accounting rules for the trawlers are different, since the entire crew have fixed wages in addition to a percentage of the catch. In 1980, fixed wages amounted to about 24% of the total wage expenses for offshore trawlers above 200 gross register tonnes (the Profitability Study (LU)). For this reason, 24% of total payment to workers is recorded as a non-catch dependent variable cost, and the remaining 76% as a catch dependent variable cost.

Table 12: Variable expenses per vessel for TRAWL divided into periods.

Catch period	1	2	3	4
Catch dependent variables	358,599	428,613	201,964	236,074
Non-catch dependent	375,866	471,425	254,825	363,125
Variable catch expenses	734,465	900,038	456,789	599,199
Variable expenses per kg	2.19	2.25	2.42	2.71
Average variable expenses per kg during the year				2.35

In Table 13, the total expenses (also estimated costs) are recorded as a function of various incomes from 50,000 to 100,000 Nkr per man and working year.

Table 13: Total expenses per kg raw material landed by TRAWL as a function of a reference income.

Referene income	Mean expenses per kg
50,000 (670)	4.33
60,000 (804)	4.45
70,000 (938)	4.56
80,000 (1,072)	4.68
90,000 (1,206)	4.80
100,000 (1,340)	4.92

2.2.5. Summary of fleet profitability and employment

Figure 3 contains a summary of the results obtained so far, and compares the total expenses per kg of the quantity of raw material landed by the different groups of vessels. The raw material expenses are here illustrated as a function of calculated wage expenses.

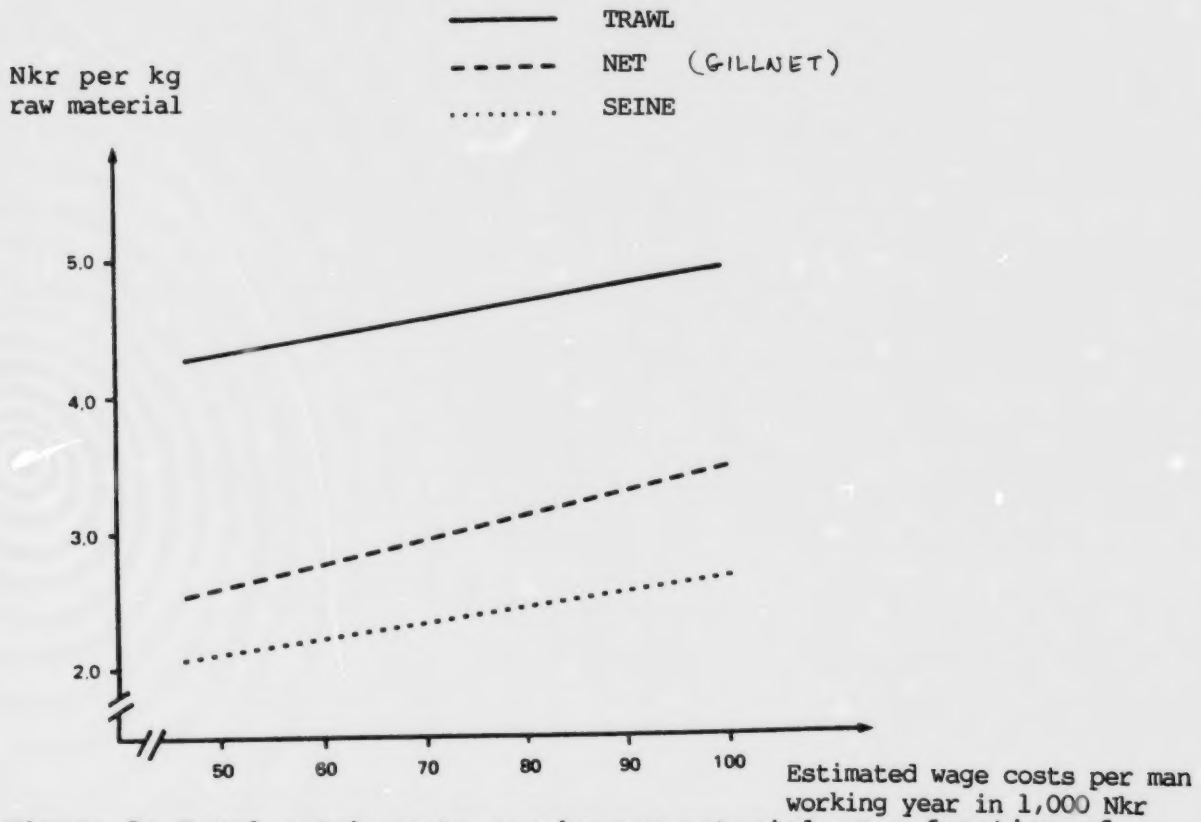

Figure 3: Total catch costs per kg raw material as a function of estimated wage expenses per man and year worked.

The total catch expenses for the trawlers are about 50% higher than for the NET group when the reference income is set at 80,000 Nkr per man and year worked. The catch expenses for the SEINE group are about 20% below the figures for the NET group of vessels.

The figure also shows that NET would be a little more sensitive to wage increases than SEINE and TRAWL. This has to do with the fact that NET's figure for wages is 1.43 Nkr per kg, while the corresponding figures for SEINE and TRAWL are 0.98 and 0.94 Nkr, respectively, for a calculated wage of 80,000 Nkr. Conventional inshore fishing (NET, line, longline) is, according to these calculations, 40-50% more labour intensive than trawling or seining.

Up till now we have only focused on the costs for the current vessel groups. According to the Profitability Study (LU, 1980), the wet fish trawlers received 4.21 Nkr per kg of raw material landed. With our calculated wage per man and year worked, this gives a deficit per vessel of about 0.5 million Nkr. The wage per worker was in reality 130,000 Nkr per year in 1980, leading to an operating deficit of about 1.2 million Nkr per vessel.

The NET vessels are relatively profitable. The average invoiced price in 1980 was 3.29 Nkr per kg, according to the Profitability Study (LU). If we base our calculations on the raw fish prices

that were in force from May 25 - Sept. 28, 1980, the average price per kg of raw material would be 2.57 Nkr. We then assume that about 65% of pollock caught in seines is delivered ungutted, heads-off. With the reference income used here, we would get a surplus, after deduction of all expenses and depreciation, of 0.14 Nkr per kg.

Based on these calculations, only the offshore trawlers would operate with a deficit.

In Chapter 4, the various fleet types will be combined in different configurations in a mathematical model where the total profitability and employment are calculated for a number of alternatives.

3. TYPES OF INTERIM STORAGE

3.1. Long-term storage of pollock

Releasing live pollock into ocean storage bags is something that has been done for a number of years. It has been necessary because the actual capacity for receiving fish has been exceeded. When we talk about actual receiving capacity, it is because pollock fishing often has reached record levels during the time the processing industries are giving vacations to their employees. Up to a few years ago, releasing live fish in bags was used only for short-term storage in 20 - 30 t bags, and the danger involved was born by the fish only. Since the supply of raw material (particularly cod and haddock) has declined severely during the last few years, the fillet industry has had to make ever greater efforts to satisfy their needs for raw material. Long-term storage of live pollock is one of the methods of interim storage that has been used in this connection. Long-term storage is done as follows: the fishermen haul live pollock from the area of catch in 20-30 t bags to the long-term storage, each one of which holds 200 t of live fish. Well boats are also used for the transport from the area of catch to the "giant bag". These bags are gradually filled during the season, all depending on the other raw material supplies (other fish species) for the fillet industry, and on the receiving capacity existing at the particular time. The way the market conditions are now, there

will be no problem selling the products, but overstocking in finished products has previously led to a reduction in pollock purchases, since this fish species has been a bit more difficult to market than cod and haddock.

The matter of responsibility was radically changed after long-term storage was introduced. The fishermen are not at risk after the fish have been weighed-in and placed in the "giant bag", and any losses are covered by the business(es) that have bought the fish. The weighing-in of live pollock has posed serious difficulties, and must be considered one of the greatest technical problems of long-term storage. The problem is that up to now there has been no efficient weighing-in technology that registers the actual quantity, without exposing the fish to further stress. A varying quantity of (ocean) water weighed in at the same time as the fish, has resulted in a "temporary" catch value to the fishermen, and it has therefore been difficult to exactly measure losses. The last element is very important when determining whether it is acceptable from biological and economical viewpoints to be involved in this type of interim storage of fish.

3.1.1. Long-term storage of raw material as short-term adjustment.

For the fillet industry, the agreement between the Union of Norwegian Food, Drink and Tobacco Workers (NNN) and the

employers' association of the food industry stipulates a 3 day advance notice for lay-offs caused by temporary undersupply of fresh raw material. Otherwise, the main agreement between the Norwegian Trade Union Confederation (LO) and the Norwegian Employers' Association (NAF) is in force, which stipulates a 14 day advance notice of lay-offs. This ensures that management makes a prognosis for the raw material supply for at least three days ahead, in order to avoid having to pay unnecessary compensation to the workers. Even if a company is capable of producing more labour intensive products, there are each year a number of lay-offs of production workers in the fish processing industry.

When the company has kept live pollock in storage and has a reasonable supply of transport vessels (well boats), lay-offs are radically reduced. If a company's raw material situation is such that it risks being without raw material only for short periods, repeated lay-offs of the work force will in the long run harm the company, in that qualified workers will not apply for jobs with this company. From the viewpoint of short-term adjustments, the company will consider wages as a fixed cost. This means that the company accepts a lower marginal revenue during these periods in order to keep production going.

The following contains data from 5 out of 9 long-term storage sites in Finnmark County, gathered in 1979. In 1978, the total capacity was 8 million kg. The price paid for round pollock

varied from 1.26 to 1.64 Nkr per kg, and net raw material cost expresses the price for round fish with adjustments for waste. The regular landed price is listed in the table as 2.028 Nkr per kg. Product cost estimates have been made earlier, where the price (net) paid for pollock is assumed to be 2.02 per kg of gutted, head-off weight. Therefore, this price will be used when the price for stored pollock is compared to the price for fish delivered round (established by the Norwegian Raw Fish Association).

There are many reasons for the losses. For example, there have been a number of serious accidents during the hauling-in of fish in storage, which have resulted in heavy losses. Table 14 (data from OUF) shows that the loss percentage varies from 8% to 38%, but 3 of the 5 projects indicate a loss of around 16%. Many of the problems with the hauling-in of stored fish must be characterized as transitory and they should be eliminated with greater experience in the technique. Based on this, it appears realistic to set the death rate at about 10-12%.

Besides the raw material costs, the other costs per storage facility vary from 0.49 to 1.13 Nkr per kg of whole fish. Such a large variation leads to very different economic results. Still, it is possible to find some of the reasons for this in the data material:

1. The cost of freight for filling and hauling depends on the distance between the catch area and the storage site, and from the storage site to the production industry.

2. Wages paid to the storage guard and for filling and hauling-in of the bags will vary from one facility to the other, depending on the location of the bags. Whether outside workers must be hired, or whether the workers employed by the company are used for this work, will affect the wage costs (available labour = wages as fixed cost).

3. The interest costs must here be "divided" into two parts: Mortgage interest and interest on operating credits (capital investments in fish). The interest on operating credits would be constant per kg (if money is borrowed for all purchases), while the mortgage interests depend on how the facility is financed.

4. Depreciation (book value) per kg of fish will depend on the purchase value and on capacity utilization (how old the facility is, and whether it has been fully written-off).

5. The insuring of such risk-bearing undertakings has turned out to create variations in the insurance premiums of different insurance companies. This still does not explain why the cheapest insurance is 50 times cheaper than the most

expensive. It seems likely that there are deficiencies in the data material from OUF.

Table 14: Data for 5 long-term storage sites for pollock. Source: The Agency for Co-operative Development of the Fisheries in Finnmark County (OUF)

Stored quantity		1000	467	636	
Loss in % of purchase	15.0	8.0	16.8	38.0	16.6
Net raw material cost	1.65	1.545	1.479	2.26	1.744
Net purchase freight	0.09	0.137	0.132	0.132	0.179
Sales freight fr. bag	0.03	0.231	0.130	0.453	0.234
Rent for guard vessel			0.09		0.108
Wages (incl.soc.benefits)					
- Placing/hauling-in bags	0.01	0.01		0.180	0.134
- Guard	0.01	0.002			0.194
- Removal of fish fr.bags	0.05				
- Other	0.01	0.011			
Interest	0.10	0.100		0.120	0.047
Insurance	0.06	0.002		0.103	0.067
Depreciation	0.09	0.037	0.017	0.04	0.10
Other	0.04			0.016	0.069
Total per kg delivered to processing company	2.14	2.095		3.304	2.876
CONVERTED to gutted/head-off (70%)	3.10	2.99		4.72	4.108

A/S Fish Processing was involved in long-term storage in 1980 with relatively good results. About 700 t in all were stored in a co-operative facility and the total loss was calculated at about 12%., whereof 7.5% was unexpected losses. It was calculated that the weight loss was about 1.5% and the blood loss 3%.

On the basis of the financial accounts for the storage and other

information from the company, the following cost estimate was set up.

Table 15: Raw material costs for stored live pollock

Raw material (net price)		2.02 Nkr
Waste (12%)	0.24 Nkr	
Freight	1.07	
Wages, maintenance and administration	0.24	
Bleeding, gutting	0.20	
Misc. (equipment)	0.05	
Capital expenses	0.45	2.25
Total raw material costs		4.27 Nkr

The item 'capital expenses' includes insurance, overdraft interest including bank commission on overdraft limit, mortgage interest and normal depreciation for the net bags.

This year (1981) there will be an extra subsidy for pollock in long-term storage of 0.70 Nkr per kg of round fish (the Raw Fish Association). This corresponds to 1.00 Nkr per kg of gutted, head-off weight. According to the above cost estimate, raw material from long-term storage will be 1.25 Nkr more expensive for the company as compared to the regular price of raw material.

When production wages are considered as a fixed cost, we would obtain, according to the cost estimates (see Section 2.1.4) a marginal revenue for block production of 4.61 Nkr, and for 5 lbs.

consumer packages the marginal revenue would be 6.13 Nkr per kilo of fillet. This gives the following marginal revenue for the two products where the raw material consists of pollock from long-term storage (Nkr per kg fillet).

	Consumer pack.	Block
Regular marginal revenue	6.13	4.61
Cost increase	2.27	2.23
Marginal revenue	3.86	2.38

If we assume a waste of 12% and that the costs of insurance, overdrafts, mortgage interest and depreciation per kg of stored fish are constant and that the other storage expenses may vary, the results are shown in Figure 4. Other storage expenses are here a linear function, so that the break-even marginal revenue can be calculated.

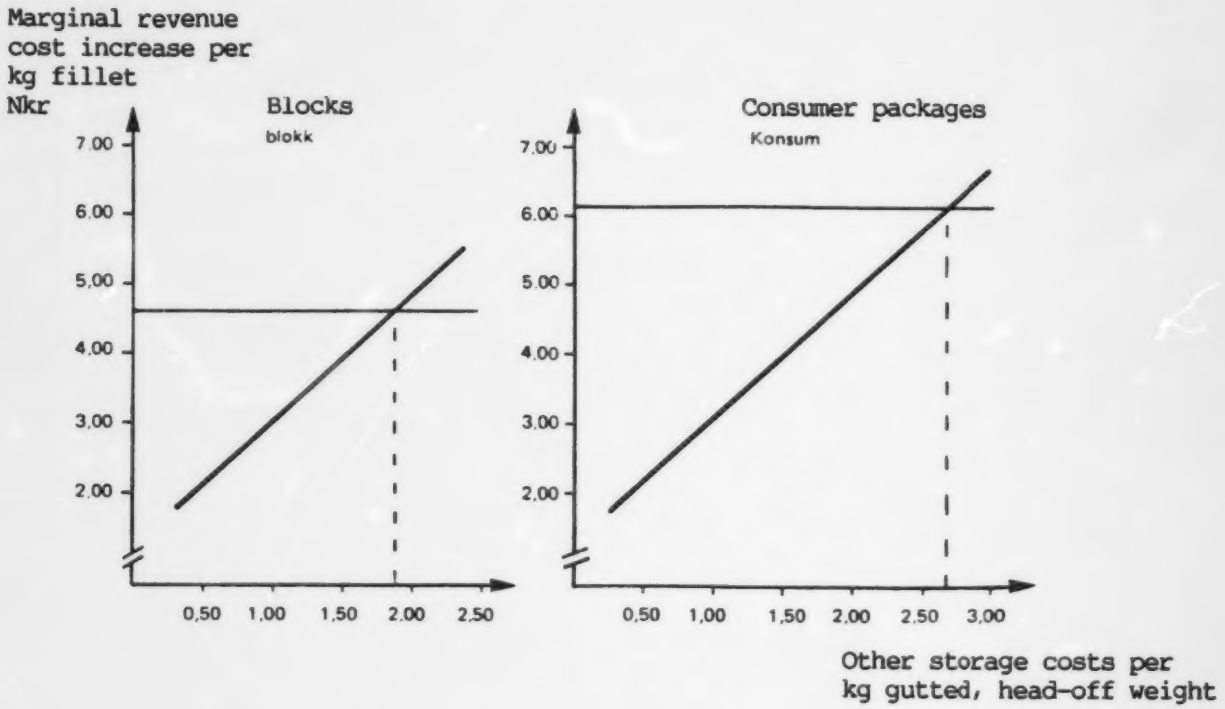

Figure 4: Marginal revenue and cost increases for production of pollock from long-term storage, where production wages are considered as a fixed cost.

db_b = marginal revenue - block
db_k = " " - consumer package
mk_b = cost increase - block
mk_k = " " - consumer package

As Figure 4 shows, we would get a marginal revenue = 0 for block production when other storage costs are 1.89 Nkr per kg of gutted, head-off weight. This corresponds to total cost increases of 2.58 Nkr per kg. Corresponding figures for consumer packages are 2.68 Nkr and 3.37 Nkr as the total.

3.1.2. Processing live pollock from long-term storage to achieve a long-term balanced production

Seasonal fishing can result in complete or partial shut-down of a number of fillet plants along the coast, which do not have a mixed fleet. The business then deems it necessary, for economic reasons, to lay off some or all of its work force. The alternative to lay-offs is to purchase raw material at such a low price that the marginal revenue becomes acceptable, since we are here dealing with quite long periods of time.

During long-term adjustments, the company will regard production wages as a variable cost. Similar calculations can then be done as were done previously for short-term adjustment. The marginal revenues for live pollock from long-term storage used for long-term adjustments of production, will then be as shown below.

	Consumer pack.	Block
Regular marginal revenue	2.84	2.26
Total cost increase	2.27	2.23
Marginal revenue per kg of fillet	0.57	0.03

As can be seen from the calculations, both block and consumer package production result in a positive marginal revenue. According to this, block production will give only 0.03 Nkr in

marginal revenue per kilo of finished product, and this must be considered unacceptable. Whether a marginal revenue of 0.57 Nkr is sufficient for such a production, must be evaluated by each individual business.

Live pollock from long-term storage will be used only for production of consumer packages and, this coincides with the normal production planning during low seasons, when the production of labour-intensive products is preferred.

We have so far worked with a calculation of 12% for constant waste. In order to clarify the relationship between total cost increases for storage, waste and "other" storage costs, we have developed a graphic illustration which shows this. The waste percentage ranges from 5% to 20% and "other" storage costs from 0.50-3.00 Nkr per kg gutted, head-off weight.

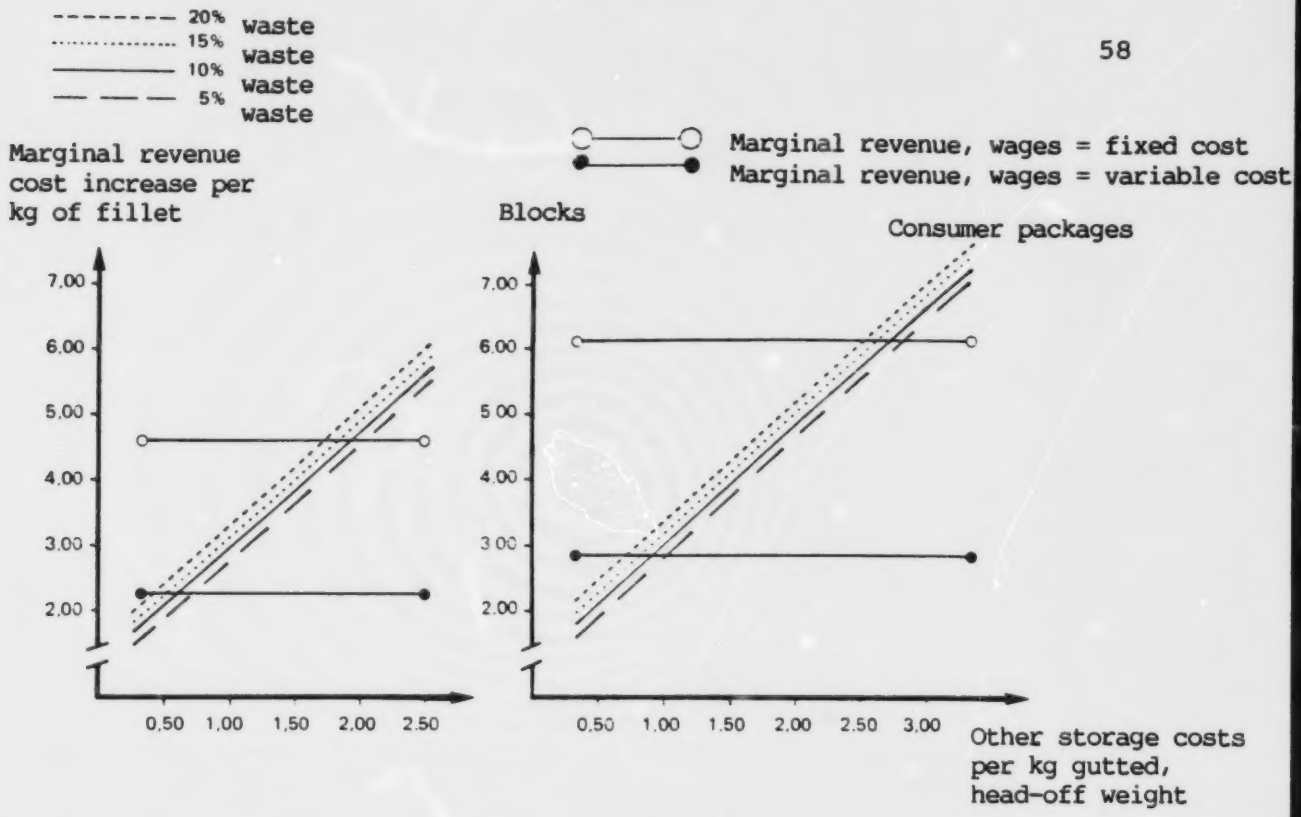

Figure 5: Cost increase as a function of waste and storage costs.

3.2. Re-freezing

As an alternative to reducing seasonal production, re-freezing of raw material is utilized by the fillet industry. The term 're-freezing' means freezing of raw material followed by cold storage and subsequent defrosting and production, as needed (Magnussen, 1977). There has been a general resistance to freezing foodstuffs several times due to the loss of quality. However, studies have shown that there is no discernable change in quality when freezing fresh fish of good quality. The outcome will depend on a number of factors, which we will discuss further on.

We have not been able to obtain any statistical data from the Norwegian Raw Fish Association on re-frozen quantities. This production method was put into use in the early 60's, but it was not until after 1970 that it was used on a large scale. It is mainly cod and haddock that are re-frozen, and the constantly reduced quotas for offshore fresh fish trawlers for these fish species, as well as the overall resource situation, have become a contributing "catalyzer" to the developments in technology and food chemistry that have taken place within this field. A number of industries have tried this method of interim storage, but far from all have had satisfactory results.

The quality of the raw material has, in most cases, been too poor, although the technical side of this production method has been mastered. A good indication of this is that most of the efforts have dealt with defrosting and production, while the treatment and correct freezing of the catch, which are vital to the quality of the end product, have been given much less attention.

3.2.1. Criteria for good production results.

The quality of the raw material always determines the quality of the end product. Since we have to count on a decline in quality when re-freezing, extra strict requirements must be made on the

quality of the raw material used, in order to obtain a good end product.

It is a well-known phenomenon that cod and haddock become "soft" during the summer, even if the treatment of the catch is good (bleeding, gutting, washing, icing). This phenomenon is explained by the annual spawning time of the fish, its feeding habits, and the composition of its food. Food containing bait (dead animal tissue) initiates enzymatic processes and leads to less firm fish flesh even if it is stored only for short periods. Poor fish flesh consistency, combined with physical stress on the fish (bending during production, pressing during freezing) will cause the fillets to crack and lead to "drip losses" during defrosting. The "drip losses" occur when liquid in the cells is forced out and then freezes into ice crystals. During defrosting, this liquid will not be fully re-absorbed by the cells, and "drips" off the fish (Magnussen, 1977).

The best raw material quality is obtained when the fish is frozen before **rigor mortis** occurs. This is related to the cracking of fillets and drip losses during defrosting. Torry Research Station, Aberdeen, Scotland, has developed data for the onset of rigor mortis and when it disappears for some fish species.

Table 16a: Onset of **rigor mortis** in fish at various storage temperatures and degrees of stress. Source: STI (The National Norwegian Institute of Technolcgy), "Re-freezing" (1979)

Fish species	Temperature	Time from landing on deck to onset of **rigor mortis**	Time from landing on deck until **rigor mortis** disappears
		Hours	Hours
Trawled cod	Iced	2-8	20-65
	4°C	4.5-8.5	54-64
	6-7°C	5	45
	17°C	2-5.5	16-20
Cod resting in aquarium	4°C	14-15	72-96
Trawled Norway haddock	Iced	22	120
Trawled whiting	Iced	1	20
Trawled plaice	Iced	7-11	54-55
Trawled pollock	Iced	18	110
Trawled haddock	Iced	2-4	37
	12°C	2	24

As shown in Table 16, haddock should be frozen first, while Norway haddock and pollock can be stored longer before freezing takes place. It is also worth noticing that the fishing gear

expose the fish to stress, which causes an earlier onset of rigor mortis.

Based on the above criteria, the freezer trawlers are best equipped for delivering quality raw material for re-freezing. A study done by The National Institute of Technology at Narvik also shows this. Only in periods with an unusual abundance of fish, could a decline in the quality of the fish occur, due to insufficient processing capacity on board. The report also shows that the physical condition of the fish (its natural quality) also determines the production results. Winter cod[1] and cod caught in summer in Finnmark County are in this respect comparable. The fish had entered **rigor mortis** and were frozen ashore. The winter cod has a better consistency after defrosting and gives far better production results than summer fish from Finnmark County that is frozen whole.

3.2.2. Freezing whole - industrial fillets

At this point I will not discuss all the available freezing and defrosting techniques, but only briefly mention the two methods used. The term freezing round means first time freezing of gutted, head-off fish. Freezing is done either in trays in a tunnel freezer, single piece freezing, or on freezer shelves. The

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[1] Transl. note: Norw. 'Lofotskrei': term used for cod caught around Lofoten - its spawning grounds - from January to April.

second method of freezing raw material is the freezing of industrial fillets (raw fillets). The fillets contain both skin and bones and are packed in blocks for further interim storage in cold storage. If the method is single piece freezing in a tunnel freezer, the necks will quickly turn yellow and the quality of the by-products is decreased. If industrial fillets are produced, the problems with poorer quality by-products are eliminated, since these are only frozen once. Less cold storage capacity is required for the re-frozen raw material, but this method of production requires a high capacity for cutting.

3.2.3. Cost estimate for re-frozen raw material at A/S Fish Processing

As the situation is right now at A/S Fish Processing, it would not require large investments to begin using re-freezing. The cold storage presently has an excess capacity, and should industrial fillet production be introduced, the cutting capacity is of such a size that it would not become a bottle-neck. During regular production it is cutting, packing and weighing that are the limiting sectors in the production. So investments are only needed for a defrosting facility. However, a minimum of investment will be required, if defrosting according to the "tray method" is chosen. Due to the fact that there is a big difference between the results of processing raw material from freezer trawlers and raw material frozen ashore (particularly summer fish

in Finnmark County), I will separate these two situations in the calculations.

3.2.3.1. Additional investments

Let us assume that A/S Fish Processing is investing in tunnel defrosting with a capacity of 20 t raw fish per 24 hours. This appears to be a suitable capacity when the day-time capacity in the fillet department for block production is around 30 t raw fish. We can count on some supplies of raw material even in slow periods. On the condition that the existing freezer tunnel can be used, about 300,000 Nkr will be required for it. Because the tunnel is to be used both for freezing and defrosting, its existing insulation must be replaced with water-resistant material, since there will be great changes in temperature and a lot of condensation in the tunnel. "Traditional" insulation materials would be destroyed within a short time with this type of operation. The economic life of such equipment is 5 years, according to STI (National Institute of Technology). Depreciation would then be 60,000 Nkr per year.

3.2.3.2. Raw material costs

Re-freezing results in a cost increase for the raw material, and this is expressed in the form of lower fillet yields. I here assume that the raw material purchased is paid at net raw

material price, even though freezer trawlers (independent shipping companies) in reality get a premium price for the raw material they bring ashore. This premium amounted to 0.26-0.50 Nkr per kg in 1980 for one company in Troms. However, it hardly seems probable that A/S Fish Processing would have paid premium prices to the trawlers of Offshore Fishing, if these were freezer trawlers. If they did, a large portion of the additional price would have gone to wages for the crews. Bunker subsidies, however, would mean that the added income remained within Offshore Fishing, and would then be considered as an internal transfer (Flåten, 1979).

The companies in Finnmark County, where cod and haddock caught during the summer were frozen ashore, had an average yield loss of 8% and 10%, respectively, for the two species. The yield loss for production of raw material from freezer trawlers is estimated at 5%. Both figures for yield loss do not include the addition of polyphosphate. If phosphate is used to compensate for the loss of liquid ("drip loss"), the yield per fillet would increase by 2-6% (Melbu Fishery Industry). This substance is prohibited in some markets (National Institute of Technology) and my calculations will therefore be made for production without this additive.

Based on my division into fish types, I will set the loss for frozen cod/haddock at 8%. This is explained by the fact that only just over 17% consists of haddock, while cod represents no less

than 77% of this company's raw material purchases. Norway haddock, Atlantic catfish and Greenland halibut represent about 6%, but these have a yield loss of less than 8%. The average net raw fish price for cod/haddock, as previously calculated, will be 3.37 Nkr per kg of raw fish. For reasons of quality, it is assumed that re-frozen raw material, frozen ashore, will only be used for block production, and that the average fillet yield for normal production will be 51% for cod/haddock. The calculations were made for fish frozen whole.

The cost increases are then:

Raw material from
freezer trawlers: 3.37 x 0.05 = 0.17 Nkr/kg raw fish
Raw material from
* freezer trawlers: (3,87 x 0.05)+0.50= 0.69 Nkr/kg raw fish
Frozen ashore: 3.37 x 0.08 = 0.27 Nkr/kg raw fish
* incl. premium price

3.2.3.3. Production costs

Extra manpower will be needed for freezing, transport to and from the cold storage, washing and cleaning. Since this is a seasonal production, I consider the wage costs as variable, and these were estimated at 0.112 Nkr per kg of raw material, according to Melbu Fishery Industry (Melbu Fiskeindustri). The general figure

according to The National Institute of Technology is 0.05 Nkr - while the figure for the Finnmark County companies is set at 0.10 Nkr per kg raw material because production takes place during peak season and the labour market is assumed to be tight. Nevertheless, both figures appear somewhat low for freezing ashore. As a comparison, let us mention that the estimates of A/S Fish Processing are about 0.20 Nkr per kg for labour expenses for freezing and defrosting of animal feed. The work procedures for freezing fish for subsequent production should be just about comparable, with the defrosting procedure added. Based on these conditions, I would estimate the labour expenses to be 0.25 Nkr per kg. Labour expenses for trawler raw material is set at 0.10 Nkr per kg.

3.2.3.4. Capital expenses

Depreciation for plant facilities is estimated at 60,000 Nkr per year in Section 3.2.3.1. As an example, if 500 t of raw material are frozen/defrosted, it would correspond to 0.12 Nkr per kg of raw fish.

Interest costs would have to be calculated both for machine equipment and for capital tied-up in raw material inventory. At a mortgage interest rate of 10% per annum, the average annual interest costs for the plant would be:

300,000 x 0.5 x 0.10 = 15,000 Nkr

With an inventory of 500 t, the interest costs for a mortgage loan would be 0.03 Nkr per kg raw fish.

The length of time raw material is stored will vary considerably depending on the supply of other raw material. For the industries that were included in the study done by The National Institute of Technology,the average storage time turned out to be around 5 months. The cost of inventories would normally be financed through short-term bank credits. This interest is assumed to be 12%. The inventory expenses will depend on the value of the inventory. Based on the principle of an average inventory and that the maximum inventory quantity is 500 t, the annual interest expenses, with a raw material price of 3.37, will be:

500 x 0.5 x 3.37 x 0.12 x 5/12 = 42,125 Nkr.

The cost per kg will be close to 0.08 Nkr. The interest expenses for trawler raw material, including premium price, will be 0.09 Nkr per kg.

3.2.3.5. Capacity utilization of the re-freezing facility - average cost increases

There will be the following cost increases per kg of raw fish for a frozen and produced quantity of 500 t (Table 17).

Table 17: Cost increases per kg raw fish due to re-freezing.

	Frozen ashore	Frozen on board	
Plant depreciation	0.12	0.12	0.12
Mortage interest	0.03	0.03	0.03
Bank overdraft interest	0.08	0.08	0.09
Raw material (Yield loss + premium price)*	0.27	0.17	0.69*
Labour expenses	0.25	0.10	0.10
Miscellaneous	0.05	0.05	0.05
Tota cost increase/kg raw fish	0.08	0.55	1.08
Cost increase/kg fillet (51%)	1.57	1.08	2.16

* incl. premium price of 0.50 Nkr per kg of raw material.

As can be seen from the table, raw material from freezer trawlers is the cheapest, if one does not have to pay a premium price for the fish. However, if such a price must be paid, it would be cheaper to freeze the fish ashore.

Out of the six cost increase components included in the calculations, depreciation for the plant and mortgage interest will be considered as fixed costs. The others will be variable and are thus constant per kg of raw fish. Based on this division into fixed and variable costs per kg of raw fish, we will obtain falling average cost increase curves with the following general formula: $Y = b + \frac{a}{x}$

for constant yield losses. If variable yield losses are introduced, the function will be:

$$Y = b + ct + \frac{a}{x}$$

where Y = cost increase per kg

X = frozen quantity

a = total fixed cost for the re-freezing plant

b = variable cost per kg

t = yield loss per kg

c = net raw fish price

For the alternatives shown in Figure 6 (the yield loss remains constant at 8% for fish frozen ashore and 5% for fish frozen on board trawlers) the relation between fixed and variable costs will differ. The magnitude of the fixed costs is assumed to be the same, while the variable costs are different for raw material frozen ashore and on board.

The curves make it obvious that the cost increases per kg would not be appreciably reduced by increasing the processing of re-frozen raw material from 300 to 500 t (60% to 100% capacity utilization) regardless of the alternative chosen. Raw material from freezer trawlers turn out to be the cheapest as long as no premium price is paid. The trawler raw material will become more expensive than raw material frozen ashore, if an additional price of 0.50 Nkr per kg is paid.

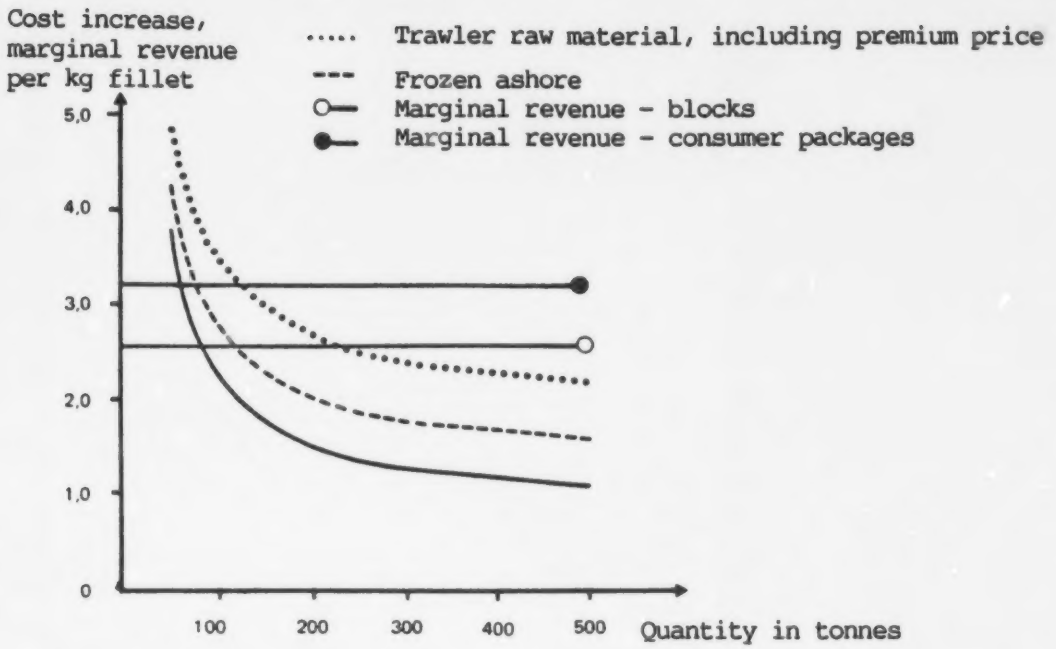

Figure 6: Average cost increases as a function of the quantity stored.

As previously mentioned, raw material frozen ashore cannot be used for consumer packages for reasons of quality. Trawler raw material, however, can be used, which gives a higher marginal revenue during production. The result of this phenomenon is that when trawler raw material is used only for production of consumer packages, the marginal revenue will be just as great, even if a premium price of close to 0.50 Nkr was paid, as for raw material frozen ashore and used for block production. The figures for a production of 300 t will be as shown below:

	Reg. marginal revenue	Cost increase per kg fillet	Marginal revenue per kg
Frozen ashore	2.87	1.78	1.09
Frozen on board, excl. premium price	3.40	1.31	2.09
Frozen on board, incl. premium price	3.40	2.41	0.99

The cost increase function is a function of the yield loss and the capacity utilization of the re-freezing facility. By varying the waste percentages from 2 to 12 and the quantity from 100 to 500 t, we obtain the continuous results shown in Figure 7.

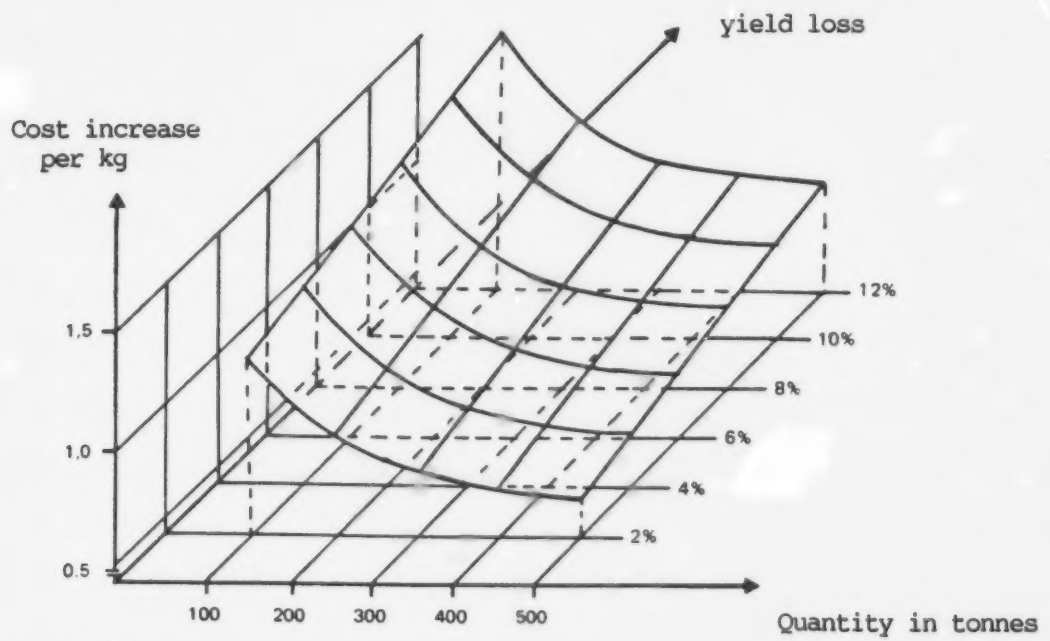

Figure 7: Cost increases per kg raw material for re-freezing ashore as a function of yield loss and quantity stored.

3.3. Product mix profit

When talking about interim storage of raw material for the fillet industry (re-freezing and long-term storage) the focus is always on the direct cost increases per kg for the storage and not on the extra income that the storage could provide. I here refer to the extra income that an improved product mix can give, as a result of a stable supply of raw material and carefully planned production.

The cost increases for interim storage were discussed in detail in Sections 3.1 and 3.2, and it will be shown here, through an example, what addition to the per kg marginal revenue an optimum product mix can give in each situation. The model in this discussion will be the fillet department of A/S Fish Processing, where two products (block and consumer packages) can be produced. An optimum product mix will here be a function of the relation between the maximum quantity that can be produced into blocks and the maximum quantity that can be produced into consumer packages per time unit, the supply of raw material and the relation between the marginal revenues from the two products. By keeping the last mentioned relation constant (which would vary for each individual company), I have used the already developed product cost estimates for pollock utilized for blocks and consumer packages. In order to show how the company's productive flexibil-

ity affects the product mix profit, I have set the capacity relation between block and consumer package at 2.0 and 1.5. The marginal revenues for block and consumer package are 2.26 and 2.84 Nkr, respectively.

Product mix profit in this context means the difference in relation to the average marginal revenue per kg with the worst possible scenario, that is if only blocks were produced. The product mix profit will also express what a processing plant with a specialized fillet department for block production could lose at various degrees of capacity utilization.

This function can be expressed mathematically as follows:

(5) $$PMG = \frac{DB1X1 + DB2X2}{X_1 + X_2} - DB_1$$

PMG = product mix profit
DB_1 = marginal revenue for block
DB_2 = marginal revenue for consumer package
X_1 = optimum quantity used for blocks
X_2 = optimum quantity used for consumer packages

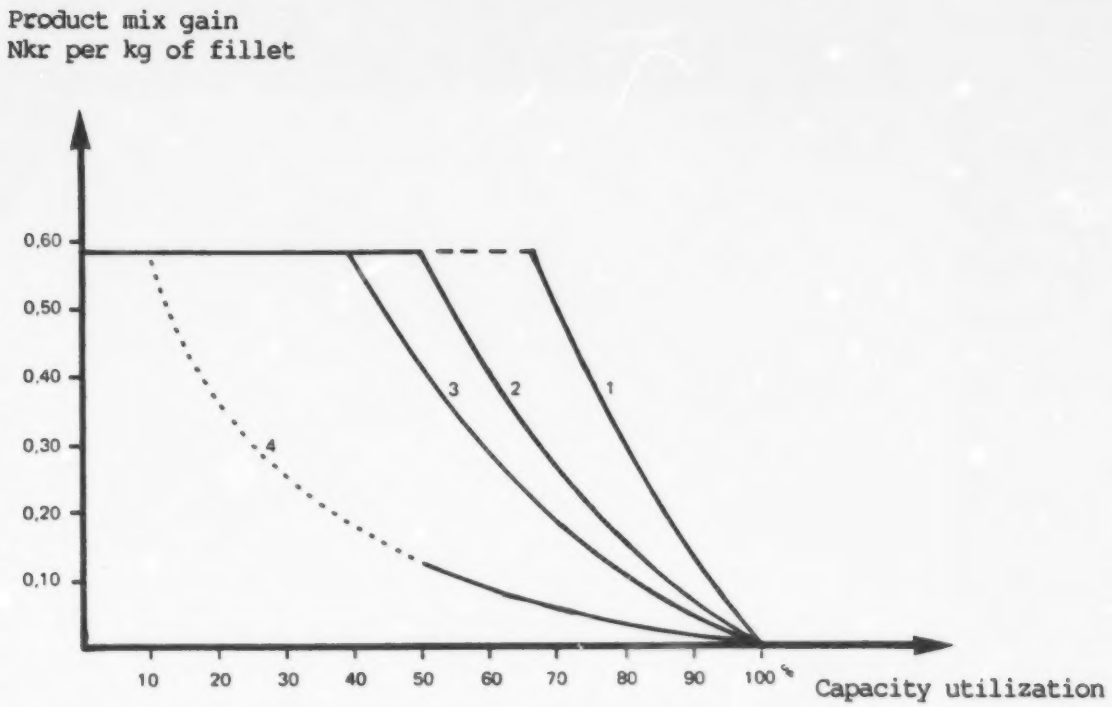

Figure 8: Maximum product mix gain with optimum product mix.

(1): Capacity relation - block/consumer pack = 1.5 (theoretical optimum)
(2): Capacity relation - block/consumer pack = 2.0 (theoretical optimum)
(3): Assumed optimum product mix [0.7 x (2)] (actual optimum)

From the figure we can draw the conclusion that the more "block specialized" a company is, the fewer are the possibilities of switching the production to higher paid and more labour intensive products by reducing the supply of raw material. It further shows that companies with a flexible fillet line (capacity block/consumer package → 1.0) will lose very little with respect to

product mix as a result of fluctuations in the supply of raw material.

With the aid of this curve we can plot the actual product mix and compare it to the optimum in order to see where a company stands in its efforts to obtain the optimum.

Based on the capacity objectives which will be used later in the LP-model[1], the total annual capacity for day-time block production would be 6,900 t raw fish at A/S Fish Processing. In 1979, according to the company's report on raw material and production, about 4,900 t were used for fillets, which corresponds to a 71% utilization of the day-time capacity of the fillet department. Of the raw fish quantity, 91.2% was used for block products and 8.8% for various consumer packages. This represents a product mix gain of 0.05 Nkr per kg fillet, arrived at as follows:

$$(2.26 \times 0.912 + 2.84 \times 0.088) - 2.26 = 0.05$$

This combination (Figure 8, curve 4) would not be the optimum. The theoretical optimum product mix at a 71% utilization of the capacity would be 59% for block production and 41% for consumer package production, with a product mix gain of 0.23 Nkr per kg of fillet (Fig. 8, curve 2).

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[1] Transl. note: Linear Programming Model

Due to the great uncertainty of raw material supplies, it is almost never possible to achieve a 100% optimum product mix, unless raw material from interim storage is available. If we assume that the fisheries industry, as a maximum, can achieve 70% of the theoretically possible optimum product mix in the production of fresh raw material, the curve for A/S Fish Processing would be as shown in Figure 8, curve 3. The values for various degrees of capacity utilization below 50% are shown for this curve.

At a 71% capacity utilization, there would, according to the curves, be a gain of 0.12 Nkr [(3) - (4)] per kg of fillet with an improved product combination as compared to the present combination. In cases where losses are caused by fluctuations in the supply of raw material, it is possible to use raw material from interim storage to compensate for the loss in this particular context (optimum product mix), but in this case, the cost increases for storage are far greater than the extra income.

3.4. The pros and cons of interim storage; if used, what method of interim storage should be chosen?

The company's normal raw material situation is the determining factor with respect to the use of interim storage. If there are large seasonal fluctuations in the supply of raw material, large quantities would have to be "moved" for production at other times

and this leads to considerable cost increases. Nevertheless, neutralizing large seasonal fluctuations results in substantial product mix profits due to improved planning of production.

When choosing between long-term storage of pollock and re-freezing, it is not enough to compare the cost increases (for the industry) per kg. The after-storage quality determines possible uses and the marginal revenue that can be expected. This was shown through a calculation where raw material from freezer trawlers was compared to raw material frozen ashore.

Therefore, it is not possible to draw any general conclusions about what method of interim storage is the cheapest. Each company, in each particular situation, must make its own calculations based on the actual circumstances at the time with respect to the above-mentioned points.

However, in this particular case, re-freezing is the cheapest choice, even when the raw material is frozen ashore. Still, the marginal revenues remain so low that it would not be economically feasible to operate with interim storage without government subsidies for this form of production.

4. THE LP-MODEL

So far we have only discussed the individual production elements in the catch and processing sectors separately. In order to get a total view of the profitability of the primary fisheries activities at the location, a mathematical model was set up where an attempt was made to find the resource structure that would produce the highest possible marginal revenue. For this purpose, the optimization method of linear programming was used. A software package called MPOS (Multi Purpose Optimalization System) and a Cyber computer was used to solve our problem.

4.1. The target function

The target function for the LP (Linear Programming) model can be established with the aid of the product cost estimates that were developed for A/S Fish Processing, the costs in the catch sector and the price subsidies for the various product uses. Included in the model are the previously introduced vessel groups, as well as deliveries from smaller fish establishments, who forward their fish to larger plants for processing. These small plants are often called PACKERS. An extra charge (packing subsidy) prescribed by the Norwegian Raw Fish Association is paid for raw material from PACKERS. The cost increases per kg in relation to the net raw fish price are shown below.

Extra price to packers	1.00 Nkr
Freight	0.30 "
- Packing subsidy	0.65 "
Cost increase per kg	0.65 Nkr

In cases where a balanced, year-round supply of raw material is discussed, long-term storage of pollock has also been included in the model. Other forms of interim storage may also be included in this kind of model, if desired. For reasons of simplicity, I chose to include only long-term storage of pollock.

As mentioned earlier, I operate with two types of fish which can be used for three different products - consumer packages and blocks from fillets, and salted fish.

The individual product uses for each delivery, can be expressed in 3 components in the model:

1) Marginal revenue per unit of quantity obtained in processing.
2) Marginal revenue per unit of quantity obtained in the catch sector, excluding price subsidy.
3) Price subsidy per unity of quantity for product use.

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All components are recorded in Norwegian kroner per kg of whole (gutted, head-off) weight. For a given product from a given type of delivery, the addition to the total marginal revenue [1)+2)+3)] can be expressed as follows:

$$DB = DB_n X_{mn} U_n + (nrp - k_m)X_{mn} + S_{nl} X_{mn}$$

DB_n = marginal revenue to business for product n.

X_{mn} = quantity from delivery type m, used for product n.

U_n = yield percentage for production of product n.

nrp = net raw fish price.

k_m = variable catch costs per kg for delivery n.

S_{nl} = price subsidy for product use n of fish type l.

Of the sizes defined in the above relation, it is only the quantity that is unknown. The expression can then be combined into a coefficient multiplied by the quantity. The coefficient expresses marginal revenue for fleet and plant for the given delivery/use.

If the coefficient is symbolized by $k_1 \ldots k_n$, and the quantities by $X_1 \ldots X_n$, the following target function will be obtained:

Maxima $k^X_1 + k_2 X_2 + \ldots\ldots + k_n X_n$

TARGET FUNCTION

	Block BLOCK		Consumer pack KONSUM		Block TORSK HYSE		Consumer pack KONSUM		Cod/haddock TORSK/HYSE		SALTING	Pollock SEI	
THAL Trawl	$2.26X_{11}U_{bb} \cdot 12.02$	$K_1 X_{11} \cdot S_{tt} X_{11}$	$2.84X_{12}U_{kb} \cdot 12.02$	$K_1 X_{12} \cdot S_{tt} X_{12}$	$2.87X_{13}U_{tb} \cdot 13.37$	$K_1 X_{13} \cdot S_{tt} X_{13}$	$3.40X_{14}U_{tk} \cdot 13.37$	$K_1 X_{14} \cdot S_{tt} X_{14}$	$0.97X_{15}U_{tk} \cdot 14.62$	$K_1 X_{15} \cdot S_{tk} X_{15}$		$0.52X_{16}U_{kk} \cdot 11.62$	$K_1 X_{16} \cdot S_{kk} X_{16} \cdot$
GARN GILL-Net	$2.26X_{21}U_{bb} \cdot 12.02$	$K_2 X_{21} \cdot S_{tt} X_{21}$	$2.84X_{22}U_{kb} \cdot 12.02$	$K_2 X_{22} \cdot S_{tt} X_{22}$	$2.87X_{23}U_{tb} \cdot 13.37$	$K_2 X_{23} \cdot S_{tt} X_{23}$	$3.40X_{24}U_{tk} \cdot 13.37$	$K_2 X_{24} \cdot S_{tt} X_{24}$	$0.97X_{25}U_{tk} \cdot 14.62$	$K_2 X_{25} \cdot S_{tk} X_{25}$		$0.52X_{26}U_{kk} \cdot 11.62$	$K_2 X_{26} \cdot S_{kk} X_{26} \cdot$
NOT Seine	$2.26X_{31}U_{bb} \cdot 12.02$	$K_3 X_{31} \cdot S_{tt} X_{31}$	$2.84X_{32}U_{kb} \cdot 12.02$	$K_3 X_{32} \cdot S_{tt} X_{32}$	$2.87X_{33}U_{tb} \cdot 13.37$	$K_3 X_{33} \cdot S_{tt} X_{33}$	$3.40X_{34}U_{tk} \cdot 13.37$	$K_3 X_{34} \cdot S_{tt} X_{34}$	$0.97X_{35}U_{tk} \cdot 14.62$	$K_3 X_{35} \cdot S_{tk} X_{35}$		$0.52X_{36}U_{kk} \cdot 11.62$	$K_3 X_{36} \cdot S_{kk} X_{36} \cdot$
PAKKERE Packers	$2.26X_{41}U_{bb}$	$FX_{41} \cdot S_{tt} X_{41}$	$2.84X_{42}U_{kb}$	$FX_{42} \cdot S_{tt} X_{42}$	$2.87X_{43}U_{tb}$	$FX_{43} \cdot S_{tt} X_{43}$	$3.40X_{44}U_{tk}$	$FX_{44} \cdot S_{tt} X_{44}$	$0.97X_{45}U_{tk}$	$FX_{45} \cdot S_{tk} X_{45}$		$0.52X_{46}U_{kk}$	$FX_{46} \cdot S_{kk} X_{46}$

K_1 = variable catch costs for TRAWL

K_2 = " " " " NET

K_3 = " " " " SEINE

F = premium price + freight for fish from PACKERS

4.2. Restrictions in the model

4.2.1 The production capacity of the plant

Based on the raw material budget established by A/S Fish Processing 1979, and the division into catch/production periods, each period has a daily production which is very close to the period average.

With the assumption that there is no labour shortage, the company's productive capacity within the periods will be as shown below (all quantities are in tonnes):

Production period	1	2	3	4
Block/cons.pack.	1770/885	2220/1110	1200/600	1710/855
Salted fish	295	370	200	285

With respect to the producessing of fillets, it is only possible to produce half as many consumer packages as blocks per day. The physical location and arrangement of the production equipment in the fillet department are the limiting factors.

As mentioned in Section 3.2.2.1., the production of salted fish is a secondary production, and the company could, of course, use its entire annual quantity for salting, if all other storage rooms were used for this purpose. The restrictions placed on this

product use are based on the plant's present processing structure, i.e. the existing production capacity for salted fish, both with respect to filling time, curing time for the fish and frequency of shipping.

The list of variables for the various deliveries/uses employed in the model are presented below:

Table 16b: List of variables

	Pollock		Cod/ haddock		Salted fish	
	Block	Cons.pack.	Block	Cons.pack.	Block	Cons.pack
TRAWL	X11	X12	X13	X14	X15	X16
NET	X21	X22	X23	X24	X25	X26
SEINE	X31	X32	X33	X34	X35	X36
PACKER	X41	X42	X43	X44	X45	X46

The consumption of resources in the fillet department can then be represented mathematically as follows:

$R_1 \ldots R_n$ is maximum available resource (capacity limit).

$$1X_{11} \cdot 2X_{12} \cdot 1X_{13} \cdot 2X_{14} \cdot 1X_{21} \cdot 2X_{22} \cdot 1X_{23} \cdot 2X_{24} \cdot 1X_{31} \cdot 2X_{32} \cdot 1X_{33} \cdot 2X_{34} \cdot 1X_{41} \cdot 2X_{42} \cdot 1X_{43} \cdot 2X_{44} \leq R_1$$

The consumption of resources in the salted fish production can be described as follows:

$$1X_{15} \cdot 1X_{16} \cdot 1X_{25} \cdot 1X_{26} \cdot 1X_{35} \cdot 1X_{36} \cdot 1X_{45} \cdot 1X_{46} \leq R_2$$

4.2.2. Quality restriction

For quality reasons, not all fish caught in nets can be used for fillet production. The percentage of fish of reduced quality will depend on factors such as:

- Time elapsed between each dragging
- Current conditions in the ocean
- Type of fishing gear used
- The critical eye of the grader

A/S Fish Processing states that it may be between 25% and 50% depending on the type of fillet that is to be produced. I will here assume that 30% of fish caught in nets cannot be used for fillet production (block/consumer package).

It is further assumed that the treatment of the catch after it has been brought on board the vessel is the same for all the vessel groups. In other words, it is only the gear used that affects the quality. The length of time that the raw material is stored on the vessels and in the plant is assumed to be such that it does not cause a decline in quality.

Of the gear used by this particular fleet, it is only the nets that reduce the quality. This means that the percentage of fish that must be used for salting will depend on the percentage of fish caught in nets.

Based on these conditions, the vessel group that will deliver raw material of which 100% can be used for fillet production is the offshore trawler group.

The net vessels also fish with lines, longline and Danish seine. The net fishing takes place mainly during the first period, but also to a lesser extent during the 2nd and 4th[1] catch periods. It is assumed that 70% of the quantity brought ashore by this vessel group in the 1st period was caught with nets. This percentage is 13.3 for the 2nd and 4th period. This implies that at least (0.7 x 0.3) 21% in the 1st period and at least (0.133 x 0.3) 4% in the 2nd and 4th periods of NET catches must be salted. In the 3rd period, there is no net fishing in any of the vessel groups.

All the ships in the SEINE group are assumed to use nets in the 1st period, which means that at least 30% of the quantity must be salted. All cod/haddock caught in the 2nd and 4th periods are assumed to have been caught in nets. The remaining catch of pollock in the 2nd, 3rd and 4th periods is assumed to have been caught in seines.

The fish bought by A/S Fish Processing from PACKERS consists of catches made by the inshore fleet, mainly from the NET group. The

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[1] Transl. note: Original has '3rd' period - an apparent error.

quality restrictions for this raw material will be the same as for NET.

A general mathematical formula can be set up for a restriction which requires the percentage a to be salted from the delivery m for product 5, and where $X_{m3} + X_{m4} + X_{m5}$ is the total delivered quantity of the fish species.

$$a(x_{m3} + X_{m4} + X_{m5}) \leq X_{m5} \Rightarrow aX_{m3} + aX_{m4} - (1-a)X_{m5} \leq 0$$

m = 1: TRAWL

m = 2: NET (GILL-)

m = 3: SEINE

4.2.3. Raw material supply

4.2.3.1. The offshore trawlers

The total cod and haddock quota for offshore fishing was 2,505 t in 1981. In addition, there were other fish species that were not regulated by quotas, so that the total quantity brought ashore to A/S Fish Processing was 2,730 t. The restriction for a maximum 15% content of haddock in the catches is not evaluated here. The divisions into periods set up in Table 18 are based on the frequency and size of trawler deliveries in 1979.

4.2.3.2. The inshore fleet (NET AND SEINE)

Out of the total quantity of about 1.5 million kg delivered to A/S Fish Processing by the inshore fleet, a division was made among the separate production periods according to the following percentages:

1st period 18.9%

2nd period 31.1%

3rd period 36.8%

4th period 13.2%

In order to arrive at a distribution key for fish landed by the inshore fleet, I gathered reports of catches from the municipality of Sørøysund. This municipality receives almost only deliveries from the inshore fleet and the percentage distribution should therefore be about the same as for Sørfjord. The further division between vessels into the NET and SEINE groups is based on local knowledge about the fleet and its activities during the year. The division of the catch into fish types for the two vessel groups was arrived at in the same fashion.

With respect to the inshore fleet, the participation in fishing activities fluctuates during the year. This applies both to the local fleet and to "foreign" vessels. There is also enforced regulation of the pollock fishing. Due to these two factors, it

is not the same vessels that deliver to the plant during the year.

4.2.3.3. PACKERS

Raw material from these suppliers is recorded as the average quantity delivered during the last few years.

Table 18 shows a summary of the expected raw material supplies.

Table 18: Assumed normal raw material supplies and distribution.

	1		2		3		4	
	C/H	P	C/H	P	C/H	P	C/H	P
TRAWLER	770	29	920	35	434	16	506	20
NET	160	-	270	20	130	30	105	-
SEINE	134	-	23	200	-	380	50	50
PACKERS	113	-	187	-	201	10	79	-
TOTAL	1177	29	1400	255	765	406	740	70

C/H = Cod/Haddock P = pollock

The raw material restrictions for, e.g., pollock can be represented by the following mathematical formula:

$X_{m1} + X_{m2} + X_{m6} \leq R_3$ R_3 = assumed quantity of pollock delivered by raw material source m.

For the periods where no deliveries are expected of a given fish type, it must be set at zero. Cod/haddock was chosen as an example to illustrate this.

$$X_{m3} + X_{m4} + X_{m5} = 0$$

5. RESULTS

5.1. Introduction

As was revealed by the fishing costs, there is a big difference between the vessel types with respect to fixed costs; the offshore trawlers are particularly noticeable with their extremely high costs. The model deals only with variable costs. Therefore, the model cannot be used for a definite decision on what type of fleet to invest in. Separate decisions must be made regarding short-term and long-term reorganization of the fleet. The model, with its variable proportional costs, will be the basis for a short-term fleet reorganization. If the fixed costs are also included in the calculations, the total catch costs will help determine the long-term fleet structure according to the presently existing conditions.

The model is very simple, as was the intention in developing this report. However, the formulation of the model that deals with the plant appears somewhat too simple, since each step in the production is not described in the model. Therefore, some data dealing with economics and capacity are not included. This information involves mainly decision figures (key numbers) with respect to expanding the capacity of various production units. Furthermore, the model's perspective is too long-range to be suitable for production planning in the fish processing industry.

The target function summarizes all variable costs in the production of fish, from fishing itself to the end product. If there is available production capacity, an extra kilo added from a given delivery for optimum use, could result in a addition to the total marginal revenue that will appear under type of delivery/use in the target function. In the current situation, there is no question of expanding the productive capacity (or the reverse) due to a shortage of raw material in relation to the receiving capacity, and the loss of this information, as a result of the formulation of the model, does not appear significant.

In the continued discussion and presentation of the results, employment will also be dealt with in more detail.

It is the demand of the fish processing workers for steady employment during the year, that presents particular problems: frequent lay-offs in the short term, difficulties in finding qualified processing workers in the long term. The fishermen have, so far, not demanded similar rights, and must operate when there is plenty of fish is available. That the Work Environment Protection Law applies to fish processing workers but not to fishermen is typical of the situation. This organizational gap between fishermen and fish industry workers puts limitations on the fish production. It has cost the industry a great deal and will continue to do so in the future, if this situation is allowed to remain. The expansion of the fresh fish trawler fleet

can be used as an example of the price paid, and the costs related to measures to achieve a balanced supply of raw material can provide answers for what will have to be paid for regular and steady employment in the fish industry in the future. The economical costs for the businesses with respect to the last mentioned measures will be discussed a little further on.

Norwegian kroner paid out in wages will be used to measure employment. In the catch sector, an reference income of 80,000 Nkr per man and year worked will be used, while the product cost estimates will form the basis for wage payments in the processing plant. Employment in administration and permanent key positions in the production (machinists, foremen, etc.) will not be discussed, since short-term fluctuations in the supply of raw material do not affect their employment in the industry.

As mentioned earlier, the raw fish prices and subsidies prescribed by the Norwegian Raw Fish Association for the period Oct. 15 - Dec. 12, 1981 will be used. The model includes only two fish species. This phenomenon means that the earnings of the vessel groups cannot be calculated exactly. The reason for this is that there is at times a high content of other fish species with different prices. Consequently, the income distribution among the production units will not be stressed. However, total results and employment will be discussed.

Table 21 contains all the major results.

5.2. Short-term adjustment

Short-term adjustment here refers to a structure that leads to the highest possible marginal revenue when all the existing production factors are brought together, and where fixed costs are considered as given. Thus, it is assumed that in the short term no new investments can be made that would change the fixed costs.

These are the prerequisites used to determine the optimum resource utilization for maximum marginal revenue.

5.2.1. The present situation

The assumed regular supply of raw material during the year and its separation into deliveries were presented in Chapter 5. It is here presumed that all the offshore trawlers take part in the fishing activities. The supply regulations for offshore trawlers that was introduced in the beginning of 1980 will not be discussed here.

According to the cost distribution made in Section 2.2., we find that in period 1 the offshore trawlers achieve a higher marginal revenue than NET, while the SEINE group achieves the best operating results in all the periods. For all other periods (2,

3, and 4) we will find that the offshore fresh fish trawlers achieve the lowest marginal revenue.

This indicates that the trawlers are not economically competitive when the availability of fish is poor (small quantities brought ashore), but will achieve a higher marginal revenue per landed raw material when the quantities are large. The coastal fleet is therefore more suitable for marginal operations with the cost structure that exists today for this type of fleet.

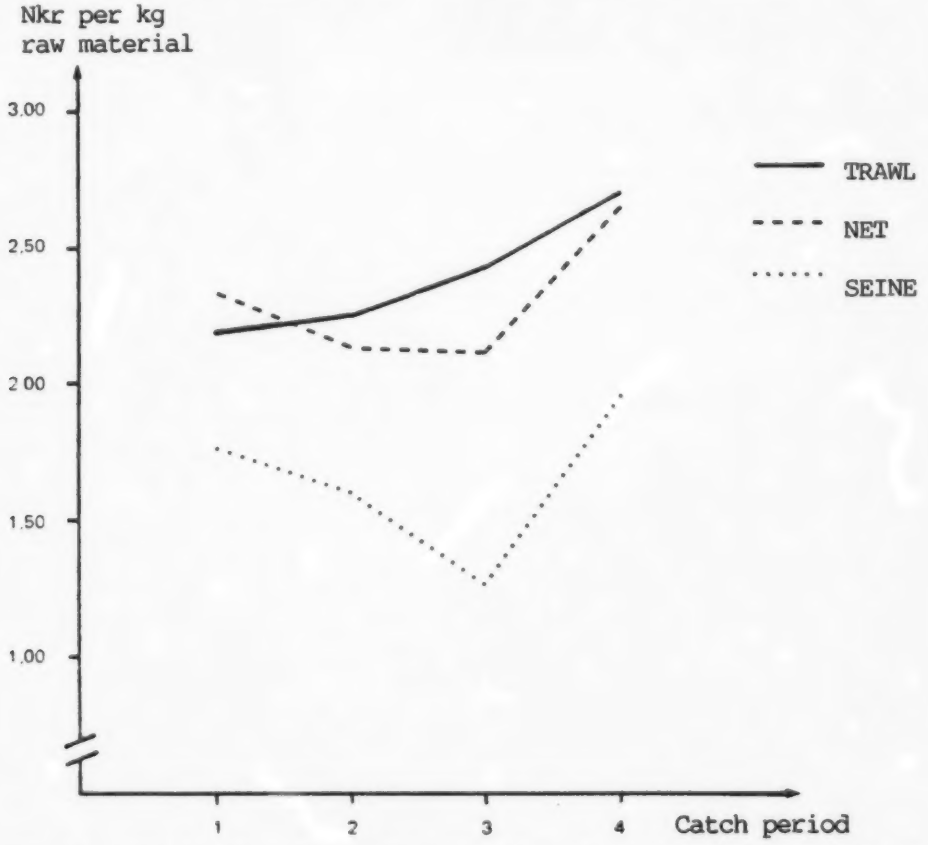

Figure 9: Variable costs per kg raw material at a given amount of fish caught per vessel.

The total marginal revenue from fleet and plant (including the finished product department) with the current fleet structure is almost 19 million Nkr, when the basis for the calculations is optimum product mix in the plant in all 4 periods. Employment in fleet and plant, measured in Nkr paid out in wages, is around 13.5 million Nkr.

Due to the fact that the plant operates with positive marginal revenues for all its products, each of the fleet types can "permit" themselves to operate with a correspondingly negative marginal revenue, before the model will reject the delivery. As long as the total marginal revenue for fleet and plant is positive, the raw material will be purchased and processed. This, of course, has to do with the fact that the productive capacity of the plant is so high in relation to the quantity brought in. If the situation instead was that the quantity of fish offered far exceeded the plant's receiving capacity, even deliveries carrying a positive marginal revenue would have to be refused. This happens during the 3rd period, when one tonne of offered raw material cannot be processed. Should the offer of fish become greater than the plant's productive capacity, it would be necessary to make a general reduction of the deliveries in the following order:

1. PACKERS 2. TRAWL 3. GILL-NET 4. SEINE

Fish that are "imported" from PACKERS will provide neither employment, nor an addition to the marginal revenue in the catch sector in this location. Nevertheless, it is only this delivery of raw material that may be expected to increase in the short term. The condition for such an increased delivery of raw material is that the price of this marginal fish is made acceptable by a positive marginal revenue during production.

Therefore, in the short term, it would be advisable to process all raw material that gives a positive marginal revenue, and it may therefore not be possible to avoid "cutting off" some deliveries, entirely or in part. The present productive adjustment would therefore be a short-term optimum.

5.3. Long-term adjustment

The affect of fixed costs on short- and long-term decisions in the production of fish (or other production) can in many cases be totally different. Since the report contains employment and profitability calculations for various fleet structures, it is necessary to explain some of the figures used.

a. Fixed costs for the inshore fleet are calculated for each kg of landed raw material. This means that for total (fixed) costs we operate with a linear fixed cost curve within the area in question, and not fixed costs that increase in a

step-wise manner, which would be the case in reality. When calculating the number of vessels that in each instance deliver to the plant, some of the results will be in decimal figures.

b. For interim storage, total costs are included in the marginal revenue figures. The result is that there will be not be any increase in the capital expenses of the plant in those cases where long-term storage of pollock is utilized.

c. Wages paid per kg of raw material for interim storage:
- long-term storage of pollock: 0.81 Nkr.

5.3.1. Present fleet structure

The total offered quantity of raw material is estimated to be 4,872 t. As mentioned in Section 5.2.1., there will be one tonne that cannot be processed, so that the total processed quantity will be 4,871 t/year.

With respect to employment, the figures are about 9.1 million Nkr paid in wages for activities ashore and 4.4 million Nkr in wages for the fishing fleet.

All depreciation figures are estimated. Depreciation for the plant was based on the fire insurance values (cf. Studies of

Fishing Industry Operations, 1980). Depreciation based on replacement values as per the Profitability Study of 1980 (LU) were used for the vessels.

According to this, the capacity and capital expenses of plant are about 9.4 million Nkr. Among the vessels, TRAWL differ greatly from the rest, with the highest fixed costs - a total of 6.4 million Nkr. With the given catch quantity it amounts to 2.33 Nkr per kg. Corresponding figures for NET and SEINE are 0.84 and 0.92 Nkr, respectively.

According to these figures, the present fleet structure results in a profit for the company of a little over 1.8 million Nkr.

5.3.2. Deliveries from the present inshore fleet only

In the study of the fleet by itself, it was found that the trawler operations result in a large deficit. What would be the consequences of selling the trawlers (possibly scrapping them), if at the same time, PACKERS and the inshore fleet would deliver only the same amount as today? The condition for taking such action would be that the present liabilities of Offshore Fishing were fully covered.

Since the trawlers today supply about 56% of the processed quantity, the reduction in quantity would also be 56%. The loss

of marginal revenues from the trawlers would be very small, while the plant would be the element that would loose most with such a policy. Nevertheless, a larger quantity could be processed into consumer packages (higher marginal revenue per unit), a fact that would somewhat compensate for the loss of marginal revenue. On the other hand, the share in per cent of the total processed quantity that would go to salting would increase. According to our prerequisites, this type of production gives a lower marginal revenue per kg. On the whole, the advantage of a better product mix in the fillet department would be 'eaten up' by reduced marginal revenue for salting. The average marginal revenue per kg would afterwards remain unchanged.

The employment provided by the trawlers would now be entirely gone, and this would necessitate a reduction in the work force of the company. Both these factors would result in a more labour intensive production, both ashore and in the fishing activities. The employment effect per kg would then increase from 2.77 Nkr to 3.41 Nkr per kg (23%). The total effect of the change in fleet structure would be a 46% reduction in employment with a 56% reduction in quantity.

The trawlers would now be eliminated, and so would their deficits. However, the loss in quantity would cause more of a decline in the overall results, than what was gained by scrapping

(possibly selling) the trawlers. The results for the fleet and the plant would now be a deficit of about 2.4 million Nkr.

5.3.3. The entire quantity provided by the inshore fleet

As shown in Section 5.3.2, eliminating the offshore trawlers would mean cutting employment by about 50%. In today's labour market situation, this would not be politically acceptable, nor would it be acceptable to the employees involved at the location. It would therefore be natural to look for alternatives to the offshore fresh fish trawlers and their deliveries. Nothing would be more natural than to invest in the vessels that bring ashore the cheapest raw material - THE INSHORE FLEET (NET, SEINE). The deliveries from the PACKERS are presumed to remain around 0.6 million kg per year, and the total raw material quantity offered is set at 4.9 million kg (as it is at present).

The raw material supply would now be of a more seasonal character, since all of it would be supplied by the inshore fleet. It is assumed that the percentages of raw material supplied in each period would be the same as with the present inshore fleet. The greater fluctuations in the supply of raw material would mean that the raw material available in period 3 would far exceed the daytime productive capacity. With a fishing fleet consisting solely of inshore fishing vessels, there would be an excess of 301 t fish in this period. Raw material from PACKERS cannot be

accepted, and the plant must also reduce its purchases from NET by 83 t of pollock, as well as 7 t of pollock from SEINE in period 3, if the objective is maximum marginal revenues.

The processed quantity with this fleet structure would be 4,571 t.

Total employment would reach present levels - a reduction of only about 1%. Due to an increased production of blocks and salted fish, the employment in the plant would be reduced by 10%, while a more labour intensive fleet structure would counteract this reduction, if we assume that the excess fish could be delivered to other places.

With the fishing sector consisting of inshore fishing vessels, the results for all the cod fisheries in Sørfjord show a surplus of almost 4.6 million Nkr, a figure that is 46% higher than today's figures.

5.4. Steady employment

In the beginning of this chapter, we mentioned that the workers in the fish processing industry have made strong demands for steady, year-round employment. Based on the raw material supplies that can be expected with various fleet structures, we have

developed a graphic presentation which shows the fluctuations in employment per working day in the 4 production periods.

Interim storage can be used to achieve both an evenly balanced production and an increase in production. Due to the present precarious resource situation of the Norwegian Arctic cod stock and of the northern pollock stock, it would be realistic to utilize interim storage as a means of increasing the produced quantities. Reaching the goal of processing any surplus fish will still not be counted as an increase in production as such. What, then, will it cost to achieve steady, year-round production without an increase in the total annual quantity?

Since in the area around Sørfjord, it is mainly long-term storage of pollock that is used to achieve a steady, year-round employment, and also for purposes of increasing production, I will primarily use this method of interim storage in my calculations. Decisions regarding amounts, time and storage method were done manually and are therefore not part of the mathematical model.

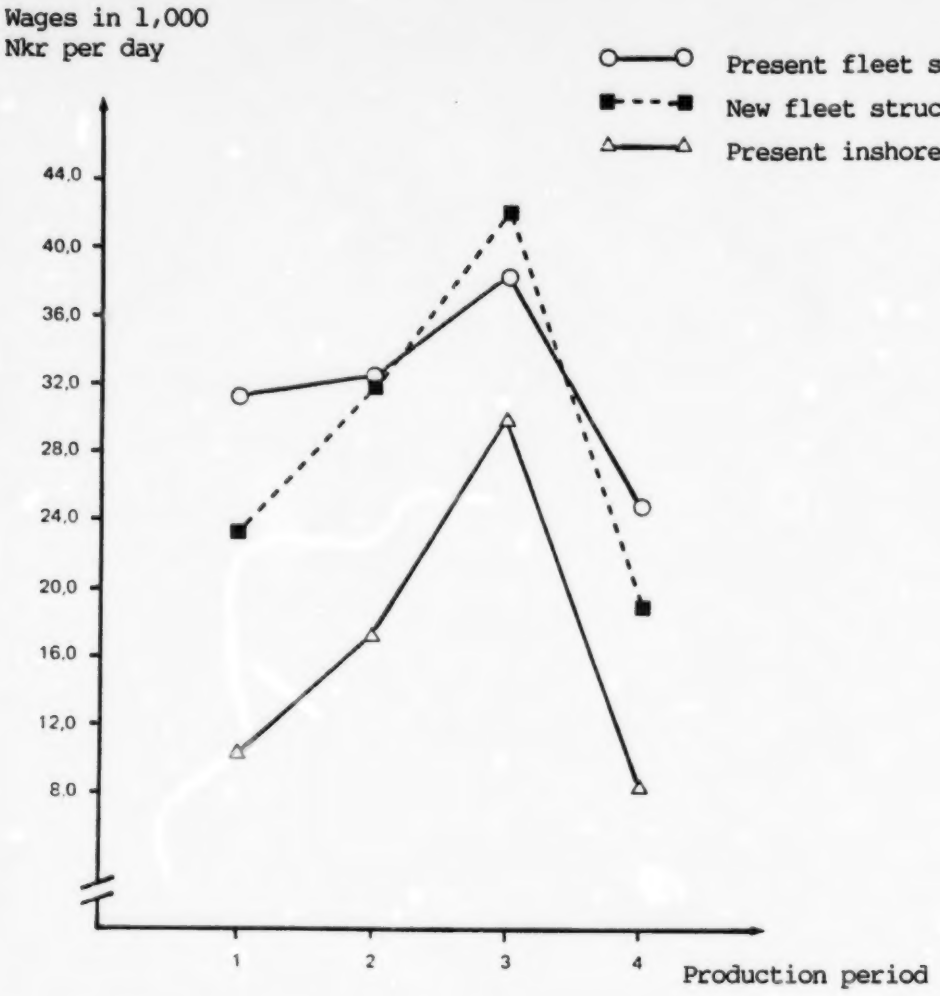

Figure 10: Fluctuations in employment per working day with various fleet structures during the 4 production periods.

5.4.1. Steady, year-round employment with present fleet structure

The total normal raw material supply is 4,872 tonnes. In order to achieve a steady, year-round production, about 21 t must be

produced per working day. The period "picture" would then be as shown below:

Table 19: Quantity requirements for an even year-round production, regular raw material supplies and quantity differences per production period.

Period	Balanced production	Regular supply	Difference
1	1250	1206	- 44
2	1568	1655	+ 87
3	847	1201	+ 354
4	1207	810	- 397
TOTAL	4872	4872	0

There will be a raw material deficit in periods 1 and 4, and a corresponding surplus in periods 2 and 3, and the following strategy was chosen: 354 t pollock are placed in long-term storage in period 3 and processed in addition to the regular raw material in period 4. Daily production would after this vary between the periods by about +/- 1 t. The balancing of raw material results in an improved year-round product mix and the overall employment effect per processed kg increases from 2.77 Nkr to 2.84 Nkr. The surplus fish (1 t) is then also included in the calculations.

The marginal revenue, and thereby also the total operating results, will be reduced by 388 thousand Nkr due to the addition-

al costs of storage. The cost increases for the plant per kg pollock in long-term storage were previously estimated at 1.25 Nkr. The "real" costs (incl. product mix gains) will be 1.10 Nkr per kg. A more balanced and steady supply of raw material has reduced the additional costs for the plant by 0.15 Nkr - gained by the product mix.

The total results with an even, year-round production and with the present fleet structure, show a surplus of about 1.5 million Nkr.

5.4.2. Even, year-round production with a new fleet structure

As mentioned before, the deliveries from the inshore fleet are somewhat more seasonal in character than the trawler deliveries. Just as the excess fish, with present fleet structure, can be absorbed in the production through interim storage, the 301 t of surplus fish from the inshore fleet can be purchased and processed also in this case. The production quantities with interim storage would therefore be the same.

Table 20: Quantity requirements and quantity differences with a new fleet structure.

Period	Balanced production	Regular supply	Difference
1	1250	925	- 325
2	1568	1602	+ 34
3	847	1701	+ 847
4	1207	644	- 563
TOTAL	4872	4872	0

Even though the time perspective in this analysis is one year, it is assumed that it is part of long-term dynamic production. For example, raw material stored in the 3rd period (year 1) can be processed in the 1st period of year 2.

With this fleet structure, 847 t pollock are stored in the 3rd period. Besides regular raw material, 541 t of the stored quantity of pollock is utilized, and the remaining 313 t are processed in the 1st period (year 2).

Interim storage with this fleet structure will have a very good effect on employment, since 301 t more raw material can be processed which otherwise would have had to be delivered to other locations. Compared to a situation where all the raw material is landed by the inshore fleet without interim storage, this even supply of raw material means 11% higher employment.

The marginal revenue and the total operating results are reduced by 458 thousand Nkr due to the additional costs of long-term storage. The results continue to show a surplus of 4.1 million Nkr. Thus, one can afford to operate with an even, year-round supply of raw material with this type of fleet structure, and the operating results (according to these calculations) are more than twice as good as what is achieved with the present fleet structure, where offshore trawlers are included.

Table 21: Summary of results for various fleet structures and production strategies

ALTERNATIVES	(1) Present fleet structure		(2) Deliveries from present inshore fleet only		(3) New fleet structure		(4) Steady, year-round employment from (1)		(5) from (2)	
QUANTITY		4871		2142		4571		4872		4872
EMPLOYMENT	7219		3564		6511		7252*		7228*	
- fillet/salted fish	1887		1887		1887		1887		1987	
- finished products	2566				2700		2566			
- TRAWL	1022		1022		2258		1022		2819	
- NET	820		820				820		2265	
- SEINE	-	13514	-	7293		13356	287	13834	672	14871
- long-term storage										
MARGINAL REVENUE			6478		15816		16732		15434	
- fillet/salted f./fleet	17120		1868	8346	1868	17684	1868	18600	1868	17302
- finished products	1868	18988								
FIXED COSTS							8349		8349	
- fillet/salted fish	8349		8349		8349		1044		1044	
- finished products	1044		1044		1044		6361			
- TRAWL	6361		-						1656	
- NET	601		601		1586		601		2126	13175
- SEINE	770	17125	770	10814	2120	13099	770	17125		-
TOTAL RESULTS		+ 1863		÷ 2418		+ 4585		+ 1475		+ 4127

* This difference is the result of a small change in the quantity from interim storage

5.4.3. Interim storage - effects and costs

As shown in Chapter 3, the costs are higher than the extra income that can be expected from interim storage. The industry should therefore not normally be interested in this form of production, as long as wages are considered a variable cost for the company. If the surplus fish were to be processed at peak seasons, it would probably lead to better operating results than if interim storage were utilized. The industry would also lose (in the short term) in marginal revenues with interim storage.

Fishermen depend on being able to sell their catch in all seasons, even at the peak of a season. If interim storage of raw material would enable the fishermen to fish more intensively while supplies are good, or if the quantities caught could be increased, it would benefit the vessels. However, on the macro level it is not realistic to increase the quantity due to the existing resource situation.

The fish industry workers would probably be the group to benefit most from a steady, and perhaps increased, production. Improved utilization of raw material (degree of processing) and increased quantity would therefore give the industrial workers more employment (higher income).

According to a company which, until recently, utilized transport of live fish (well boats), wages to the crew amounted to about 35% of the total income from the transport. If we further assume that 100% of the item "wages, maintenance and administrative expenses" is used to pay workers, only 0.81 Nkr of the total additional costs (excl. subsidies) of 2.25 Nkr per kg will go to the work force. Wastage and capital expenses thus amount to 1.44 Nkr per kg. This corresponds to 36% for labour and 64% for capital.

As previously shown, there was in one case a product mix gain of 0.15 Nkr per kg for interim storage. This phenomenon does not disrupt the division between labour and capital by more than 2-3% in favour of labour.

Interim storage of raw material, however, is a means of strengthening and balancing the employment over the year. One of the conditions for receiving a government subsidy for fish from long-term storage is that it be used for fillet production. Therefore, the extra costs for storage should, in principle, be debited to the factor one wishes to stimulate, in this case labour (Olsen, 1979).

If the alternative to interim storage is a seasonal type of production, an interesting question will arise: How much should the workers be paid to work more during peak seasons in lieu of free

time during slow seasons? This will not be discussed here, however, but I would just like to point out a few items in this context. If the wage increase needed to make the workers accept a more seasonal type of employment is lower than the extra costs for interim storage, as calculated here, the industry would benefit from a seasonal production. An increase in wages would be a direct addition to labour (employment), while interim storage costs primarily are capital expenses and losses in the form of waste and fillet yields.

5.5. Transition to a new fleet structure

In this discussion, the prerequisite is that A/S Fish Processing must maintain its operations, while the fishing fleet is viewed as a variable production sector. In other words, the processing costs are considered as given, and the total results for fleet and industry will be a function of the raw material deliveries.

The three structural alternatives, whose results are presented here, can be summarized - in a somewhat simplified manner - as follows:

1. "The present situation" + 1.7 million Nkr
2. Present inshore fleet only - 2.4 " "
3. New fleet structure + 4.6 " "

Figure 11 illustrates what happens if employment is also included in the same alternatives.

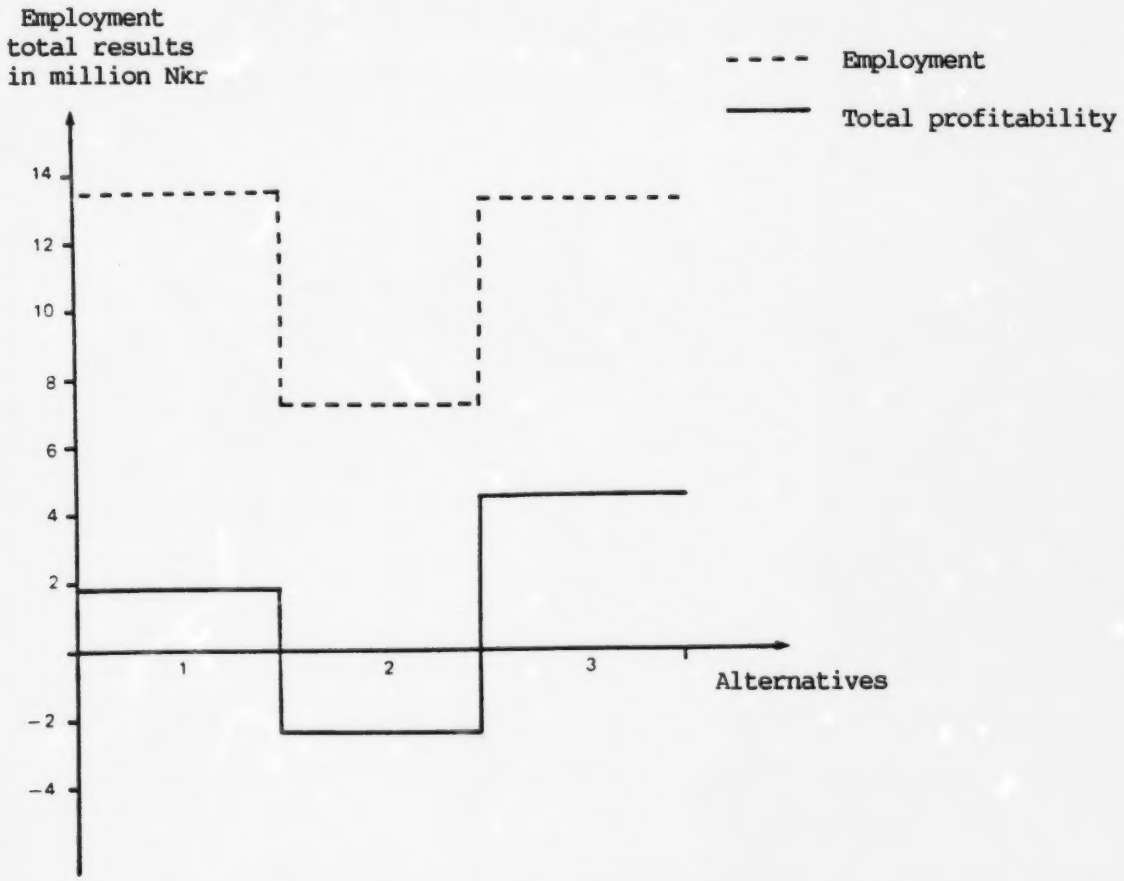

Figure 11: Employment and total operating results (1980's Nkr value)

As shown by Figure 11, alternative 3 will give the best operating results and high employment. Based on this, there is no doubt that a labour intensive type of fleet is better suited to the present resource situation than a fleet with offshore trawlers.

Another very important element when discussing what type of fleet should be favoured, is the consumption of fuel per kg of fish. The Research Institute for Fisheries Technology (FTFI - Trondheim)[1] lists the fuel consumption for inshore fishing vessels as about 0.1 kg oil per kg fish. Stern trawlers have a consumption of about 0.9 kg oil per kg fish. By themselves, these figures are not useful as a basis for decisions, but in the context of the rest of this analysis, they strengthen the comparative economical advantages of the inshore fleet. With the given quota (income), the goal would be to minimize expenses in order to obtain the largest possible surplus from the operations. With steadily rising oil prices and with the mentioned consumption of fuel, the trawlers would be more sensitive to new price increases for oil than the inshore fleet (Flåten, 1980).

A local economical goal is to restructure the fishing sector in such a manner that structure 3 is obtained. At the same time, the transition should be made as "painless" as possible for employment (a) and for each of the economic units (b).

As could be seen from the data material and the summary of results, the trawler fish was very costly. Trawlers are extremely capital intensive compared to the inshore fleet, which also shows up in the capital expenses. Of the total fixed costs of 6.3 million Nkr, 4.2 million Nkr are estimated depreciations and

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[1] Conference held at Tromsø, March 5-6, 1981.

interest on shareholders' equity. Since there is little likelihood that the fresh fish trawlers would have to be replaced, we can in reality disregard these estimated depreciations. Furthermore, the shareholders' equity must be considered as lost after many years of operating with a deficit. Interest on shareholders' capital is, therefore, not a realistic expense in this case. We are then left with costs for interest and loan payments, besides other fixed costs. The payments on mortgage loans are not known. If we disregard this expense, the fixed costs per kg of mixed raw material will be 0.78 Nkr, and the total costs per kg will amount to 3.13 Nkr. In comparison, the NET group had total costs of 3.09 Nkr per kg.

Thus, it would be profitable to fish with trawlers until they are physically unusable, or until the technical development in this field makes these vessels out-of-date as operating units. The assumption in both cases is that the sales value of the operating unit is equal to zero. If there is a sales value, the above argument would not necessarily apply.

If the offshore trawlers are scrapped, present subsidy regulations would remove all financial liability for the vessels.

If the trawlers are eliminated immediately, there would be a temporary loss in the supply of raw material, and thereby a substantial reduction in employment, which would then be built up

again in step with the expansion of the inshore fleet. If trawler operations are reduced gradually, the re-structuring would be done in a socially softer fashion. We will therefore assume that one fresh fish trawler is physically capable of surviving until the day when the last of the newly purchased inshore vessels has arrived on the scene. This assumption does not appear totally unreasonable in this case, since the newest vessel was built two years after the others.

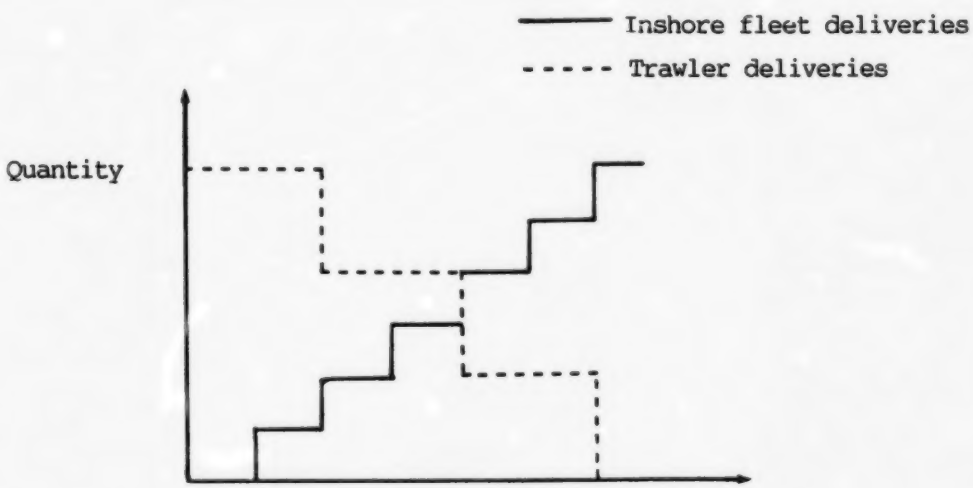

Figure 12: Substitution of trawler raw material with inshore fleet deliveries.

The offshore trawlers could be eliminated in three stages, while a number of "new" inshore fishing vessels will be required to replace them to make up for the loss of quantity. The step-wise curve for the latter vessels is not intended to express step-wise changes in the quantity per new acquisition, but is only an approximation.

The trawlers will also be very important during the reorganization stage to maintain the level of employment, and not least, in order for the industry to receive reasonable supplies, so that it can achieve a steady level of productivity.

How many vessels will be needed, and what is the amount of capital that will be required for such a reorganization? What is the time perspective of the conversion? These are questions that must be answered before making a decision about a new type of fleet structure. Two general answers can be given. - (1) For profitability reasons the reorganization should take place as quickly as possible. - (2) For employment reasons, new investments should be completed before the last "surviving" trawler is scrapped. (1) and (2) are, so to speak, at extreme opposite ends of the time perspective.

If the assumption is a quantity distribution between NET and SEINE of 44/56, (as at present), a pure division would result in a need for 6.9 NET vessels and 2.5 SEINE vessels in order to replace present trawler deliveries. With the uncertainties that characterize the fishing sector, we would need to purchase 7 NET vessels of 50 feet each and 3 SEINE vessels of 70 feet each. The prices of new ships made of wood, including fishing gear, would, according to the "BOAT MARKET" (The Fishermen's Bank Inc.), be around 3.8 million Nkr for 70 feet vessels and about 20 million Nkr for 50 feet vessels. This would require a total capital for

operating units of about 25 million Nkr (1981 monetary value), and most of it would probably have to be borrowed. It should be possible to purchase these 10 vessels within a 5 year time span, which would mean annual investments of 5 million Nkr. It is assumed that this reorganization will begin immediately.

5.6. Some remarks regarding the analysis

Many of the conditions included in this report could be the object of discussions. I will here only point out a few items.

The year has been divided into 4 catch and production periods. This does not take into account the day-to-day fluctuations that occur in the supply of raw material. The inshore fleet which consists of smaller vessels is more sensitive to bad weather than the offshore fresh fish trawlers. Since the model contains only 4 periods, the vessels in the inshore fleet have more of an advantage.

When we here suggest a change in the structure of the fleet, this is done only from the viewpoint of local industrial economics. We do not discuss the effect a reorganization of the catch sector would have on local suppliers of investment factors to the fisheries (secondary effects).

A local adjustment would only be the first step on the road towards a restructuring of the national economy. Further planning would involve a co-ordination between the local communities in one region, and then we would proceed to co-ordinate the consumption of resources between regions and various parts of the country, until the entire fisheries industry is included. This kind of planning structure can be compared to budgeting within a company. Wherever motivation on the "basic level" is absent, the value of the budget plans are minimal. Plans and guidelines originating from the "basic level", where the main guidelines are drawn up by the management, will likely increase the interest in following up on these guidelines, and compare well with a budget developed according to the "structural method".

6. APPENDIX

6.1. Explanations of the computer printouts

Due to the volume of computer printouts, I will here limit myself to presenting computer printouts where today's fleet structure is utilized.

The figures following the title refers to the catch period.

The target function is listed under "MAXIMIZE", and the restriction under "CONSTRAINTS".

Optimal product mix can be arrived at by combining "ACTIVITY LEVEL" and "VAR NAME". "VAR NAME" denotes the product, and "ACTIVITY LEVEL" denotes how much is to produced of this product.

See also Table 16b: List of variables.

6.2. Datautkjøringer. 121

Computer printouts

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*                                    *
*              M P O S               *
*                                    *
*            VERSION 4.0             *
*                                    *
* MULTI-PURPOSE OPTIMIZATION SYSTEM  *
*                                    *
**************************************

***** PROBLEM NUMBER  1 *****

      TITLE
      DAGENS FLATESTRUKTUR 1  PRESENT FLEET STRUCTURE 1
      REGULAR
      VARIABLES
      X11 TO X16
      X21 TO X26
      X31 TO X36
      X41 TO X46
      X51 TO X52
      MAXIMIZE
      2.28X11+2.57X12+4.3X13+4.34X14+3.39X15+0.61X16+2.14X21+2.43X22+3.96X23+
      4.2X24+3.25X25+0.47X26+2.71X31+3.0X32+4.53X33+4.77X34+3.82X35+1.04X36+
      0.62X41+0.91X42+0.84X43+1.08X44-0.09X45-0.35X46+1.46X51+1.75X52
      CONSTRAINTS
   1. X11+2X12+X13+2X14+X21+2X22+X23+2X24+X31+2X32+X33+2X34+X41+
      2X42+X43+2X44+X51+2X52.LE.1770000
   2. X15+X16+X25+X26+X35+X36+X45+X46.LE.295000
   3. X11+X12+X16.LE.29000
   4. X13+X14+X15.LE.770000
   5. X21+X22+X26=0
   6. X23+X24+X25.LE.160000
   7. X31+X32+X36=0
   8. X33+X34+X35.LE.134000
   9. X41+X42+X46=0
  10. X43+X44+X45.LE.113000
  11. X51+X52=0
  12. .21X23+.21X24-.79X25.LE.0
  13. .3X33+.3X34-.7X35.LE.0
  14. .21X43+.21X44-.79X45.LE.0
      OPTIMIZE
```

Resultater 1. periode

Results for period 1

VAR NO	VAR NAME	ROW NO	STATUS	ACTIVITY LEVEL	OPPORTUNITY COST	LOWER BOUND
1	X11	—	LB	0.0000000	.0500000	0.0000
2	X12	—	B	29000.0000000	0.0000000	0.0000
3	X13	—	B	231270.0000000	0.0000000	0.0000
4	X14	—	B	538730.0000000	0.0000000	0.0000
5	X15	—	LB	0.0000000	.4700000	0.0000
6	X16	—	LB	0.0000000	1.4800000	0.0000
7	X21	—	LB	0.0000000	.0500000	0.0000
8	X22	—	B	0.0000000	0.0000000	0.0000
9	X23	—	B	126400.0000000	0.0000000	0.0000
10	X24	—	LB	0.0000000	0.0000000	0.0000
11	X25	—	B	33600.0000000	0.0000000	0.0000
12	X26	—	LB	0.0000000	1.4800000	0.0000
13	X31	—	LB	0.0000000	.0500000	0.0000
14	X32	—	B	0.0000000	0.0000000	0.0000
15	X33	—	LB	0.0000000	0.0000000	0.0000
16	X34	—	B	93800.0000000	0.0000000	0.0000
17	X35	—	B	40200.0000000	0.0000000	0.0000
18	X36	—	LB	0.0000000	1.4800000	0.0000
19	X41	—	LB	0.0000000	.0500000	0.0000
20	X42	—	B	0.0000000	0.0000000	0.0000
21	X43	—	B	89270.0000000	0.0000000	0.0000
22	X44	—	LB	0.0000000	0.0000000	0.0000
23	X45	—	B	23730.0000000	0.0000000	0.0000
24	X46	—	LB	0.0000000	.7800000	0.0000
25	X51	—	LB	0.0000000	.0500000	0.0000
26	X52	—	B	0.0000000	0.0000000	0.0000
27	SLACK-- D-	1	LB	0.0000000	.2400000	0.0000
28	SLACK-- D-	2	B	197470.0000000	0.0000000	0.0000
29	SLACK-- D-	3	LB	0.0000000	2.0900000	0.0000
30	SLACK-- D-	4	LB	0.0000000	3.8600000	0.0000
31	ARTIF-- D-	5	LB	0.0000000	1.9500000	0.0000
32	SLACK-- D-	6	LB	0.0000000	3.6213000	0.0000
33	ARTIF-- D-	7	LB	0.0000000	2.5200000	0.0000
34	SLACK-- D-	8	LB	0.0000000	4.1490000	0.0000
35	ARTIF-- D-	9	LB	0.0000000	.4300000	0.0000
36	SLACK-- D-	10	LB	0.0000000	.4551000	0.0000
37	ARTIF-- D-	11	LB	0.0000000	1.2700000	0.0000
38	SLACK-- D-	12	LB	0.0000000	.4700000	0.0000
39	SLACK-- D-	13	LB	0.0000000	.4700000	0.0000
40	SLACK-- D-	14	LB	0.0000000	.6900000	0.0000

Maximum value of the objective function = 4644410.300000

UNEDITED TRANSLATION
for information only
TRADUCTION NON REVISEE

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*                                    *
*              M P O S               *
*                                    *
*            VERSION 4.0             *
*                                    *
* MULTI-PURPOSE OPTIMIZATION SYSTEM  *
*                                    *
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***** PROBLEM NUMBER 1 *****

```
TITLE
DAGENS FLATESTRUKTUR 2  PRESENT FLEET STRUCTURE 2
REGULAR
VARIABLES
X11 TO X16
X21 TO X26
X31 TO X36
X41 TO X46
X51 TO X52
MAXIMIZE
2.22X11+2.51X12+4.04X13+4.28X14+3.33X15+0.55X16+2.24X21+2.63X22+4.16X23+
4.4X24+3.45X25+0.67X26+2.88X31+3.17X32+4.7X33+4.94X34+3.99X35+1.15X36+
0.62X41+0.91X42+0.84X43+1.08X44-0.09X45-.35X46+1.46X51+1.75X52
CONSTRAINTS
 1.  X11+2X12+X13+2X14+X21+2X22+X23+2X24+X31+2X32+X33+2X34+X41+
     2X42+X43+2X44.LE.2220000
 2.  X15+X16+X25+X26+X35+X36+X45+X46.LE.370000
 3.  X11+X12+X16.LE.35000
 4.  X13+X14+X15.LE.920000
 5.  X21+X22+X26.LE.20000
 6.  X23+X24+X25.LE.270000
 7.  X31+X32+X36.LE.200000
 8.  X33+X34+X35.LE.23000
 9.  X41+X42+X46=0
10.  X43+X44+X45.LE.187000
11.  X51+X52=0
12.  .04X21+.04X22-.96X26.LE.0
13.  .04X23+.04X24-.96X25.LE.0
14.  .3X33+.3X34-.7X35.LE.0
15.  .04X41+.04X42-.96X46.LE.0
16.  .04X43+.04X44-.96X45.LE.0
     OPTIMIZE
```

Resultater 2. periode

Results for period 2

VAR NO	VAR NAME	ROW NO	STATUS	ACTIVITY LEVEL	OPPORTUNITY COST	LOWER BOUND
1	X11	—	LB	0.0000000	.0500000	0.0000
2	X12	—	B	35000.0000000	0.0000000	0.0000
3	X13	—	B	599320.0000000	0.0000000	0.0000
4	X14	—	B	320680.0000000	0.0000000	0.0000
5	X15	—	LB	0.0000000	.4700000	0.0000
6	X16	—	LB	0.0000000	1.4800000	0.0000
7	X21	—	LB	0.0000000	.1500000	0.0000
8	X22	—	B	19200.0000000	0.0000000	0.0000
9	X23	—	B	259200.0000000	0.0000000	0.0000
10	X24	—	LB	0.0000000	0.0000000	0.0000
11	X25	—	B	10800.0000000	0.0000000	0.0000
12	X26	—	B	800.0000000	0.0000000	0.0000
13	X31	—	LB	0.0000000	.0500000	0.0000
14	X32	—	B	200000.0000000	0.0000000	0.0000
15	X33	—	LB	0.0000000	0.0000000	0.0000
16	X34	—	B	16100.0000000	0.0000000	0.0000
17	X35	—	B	6900.0000000	0.0000000	0.0000
18	X36	—	LB	0.0000000	1.5400000	0.0000
19	X41	—	LB	0.0000000	.0500000	0.0000
20	X42	—	B	0.0000000	0.0000000	0.0000
21	X43	—	B	179520.0000000	0.0000000	0.0000
22	X44	—	LB	0.0000000	0.0000000	0.0000
23	X45	—	B	7480.0000000	0.0000000	0.0000
24	X46	—	LB	0.0000000	.1800000	0.0000
25	X51	—	LB	0.0000000	.2900000	0.0000
26	X52	—	B	0.0000000	0.0000000	0.0000
27	SLACK-- D-	1	LB	0.0000000	.2400000	0.0000
28	SLACK-- D-	2	B	344020.0000000	0.0000000	0.0000
29	SLACK-- D-	3	LB	0.0000000	2.0300000	0.0000
30	SLACK-- D-	4	LB	0.0000000	3.8000000	0.0000
31	SLACK-- D-	5	LB	0.0000000	2.0908000	0.0000
32	SLACK-- D-	6	LB	0.0000000	3.9012000	0.0000
33	SLACK-- D-	7	LB	0.0000000	2.6900000	0.0000
34	SLACK-- D-	8	LB	0.0000000	4.3190000	0.0000
35	ARTIF-- D-	9	LB	0.0000000	.4300000	0.0000
36	SLACK-- D-	10	LB	0.0000000	.5724000	0.0000
37	ARTIF-- D-	11	LB	0.0000000	1.7500000	0.0000
38	SLACK-- D-	12	LB	0.0000000	1.4800000	0.0000
39	SLACK-- D-	13	LB	0.0000000	.4700000	0.0000
40	SLACK-- D-	14	LB	0.0000000	.4700000	0.0000
41	SLACK-- D-	15	B	0.0000000	0.0000000	0.0000
42	SLACK-- D-	16	LB	0.0000000	.6900000	0.0000

Maximum value of the objective function = 5939365.800000

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*              M P O S               *
*                                    *
*            VERSION 4.0             *
*                                    *
* MULTI-PURPOSE OPTIMIZATION SYSTEM  *
*                                    *
**************************************

*** PROBLEM NUMBER   1 *****

     TITLE
     DAGENS FLATESTRUKTUR 3    PRESENT FLEET STRUCTURE 3
     REGULAR
     VARIABLES
     X11 TO X16
     X21 TO X26
     X31 TO X36
     X41 TO X46
     X51 TO X52
     MAXIMIZE
     2.05X11+2.34X12+3.87X13+4.11X14+3.16X15+0.38X16+2.35X21+2.64X22+4.17X23+
     4.41X24+3.46X25+0.68X26+3.22X31+3.51X32+5.04X33+5.28X34+4.33X35+1.55X36+
     0.62X41+0.91X42+0.84X43+1.08X44-0.09X45-0.35X46+1.46X51+1.75X52
     CONSTRAINTS
 1.  X11+2X12+X13+2X14+X21+2X22+X23+2X24+X31+2X32+X33+2X34+X41+
     2X42+X43+2X44.LE.1200000
 2.  X15+X16+X25+X26+X35+X36+X45+X46.LE.200000
 3.  X11+X12+X16.LE.16000
 4.  X13+X14+X15.LE.434000
 5.  X21+X22+X26.LE.30000
 6.  X23+X24+X25.LE.130000
 7.  X31+X32+X36.LE.380000
 8.  X33+X34+X35=0
 9.  X41+X42+X46.LE.10000
10.  X43+X44+X45.LE.201000
11.  X51+X52=0
     OPTIMIZE
```

Resultater 3. periode

Results for period 3

SUMMARY OF RESULTS

VAR NO	VAR NAME	ROW NO	STATUS	ACTIVITY LEVEL	OPPORTUNITY COST	LOWER BOUND
1	X11	—	B	16000.0000000	0.0000000	0.0000
2	X12	—	LB	0.0000000	.3300000	0.0000
3	X13	—	B	434000.0000000	0.0000000	0.0000
4	X14	—	LB	0.0000000	.3800000	0.0000
5	X15	—	LB	0.0000000	.0900000	0.0000
6	X16	—	LB	0.0000000	1.0500000	0.0000
7	X21	—	B	30000.0000000	0.0000000	0.0000
8	X22	—	LB	0.0000000	.3300000	0.0000
9	X23	—	B	130000.0000000	0.0000000	0.0000
10	X24	—	LB	0.0000000	.3800000	0.0000
11	X25	—	LB	0.0000000	.0900000	0.0000
12	X26	—	LB	0.0000000	1.0500000	0.0000
13	X31	—	B	380000.0000000	0.0000000	0.0000
14	X32	—	LB	0.0000000	.3300000	0.0000
15	X33	—	B	0.0000000	0.0000000	0.0000
16	X34	—	LB	0.0000000	.3800000	0.0000
17	X35	—	LB	0.0000000	.0900000	0.0000
18	X36	—	LB	0.0000000	1.0500000	0.0000
19	X41	—	B	9000.0000000	0.0000000	0.0000
20	X42	—	LB	0.0000000	.3300000	0.0000
21	X43	—	B	201000.0000000	0.0000000	0.0000
22	X44	—	LB	0.0000000	.3800000	0.0000
23	X45	—	LB	0.0000000	.3100000	0.0000
24	X46	—	LB	0.0000000	.3500000	0.0000
25	X51	—	LB	0.0000000	.2900000	0.0000
26	X52	—	B	0.0000000	0.0000000	0.0000
27	SLACK-- D-	1	LB	0.0000000	.6200000	0.0000
28	SLACK-- D-	2	B	200000.0000000	0.0000000	0.0000
29	SLACK-- D-	3	LB	0.0000000	1.4300000	0.0000
30	SLACK-- D-	4	LB	0.0000000	3.2500000	0.0000
31	SLACK-- D-	5	LB	0.0000000	1.7300000	0.0000
32	SLACK-- D-	6	LB	0.0000000	3.5500000	0.0000
33	SLACK-- D-	7	LB	0.0000000	2.6000000	0.0000
34	ARTIF-- D-	8	LB	0.0000000	4.4200000	0.0000
35	SLACK-- D-	9	B	1000.0000000	0.0000000	0.0000
36	SLACK-- D-	10	LB	0.0000000	.2200000	0.0000
37	ARTIF-- D-	11	LB	0.0000000	1.7500000	0.0000

Maximum value of the objective function = 3723000.000000

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*                                    *
*            M P O S                 *
*                                    *
*          VERSION 4.0               *
*                                    *
* MULTI-PURPOSE OPTIMIZATION SYSTEM  *
*                                    *
**************************************


***** PROBLEM NUMBER  1 *****

      TITLE
      DAGENS FLATESTRUKTUR 4    PRESENT FLEET STRUCTURE 4
      REGULAR
      VARIABLES
      X11 TO X16
      X21 TO X26
      X31 TO X36
      X41 TO X46
      X51 TO X52
      MAXIMIZE
      1.76X11+2.05X12+3.58X13+3.82X14+2.87X15+0.09X16+1.82X21+2.11X22+3.64X23+
      3.88X24+2.93X25+0.15X26+2.51X31+2.80X32+4.33X33+4.57X34+3.62X35+0.84X36+
      0.62X41+0.91X42+0.84X43+1.08X44-0.09X45-0.35X46+1.46X51+1.75X52
      CONSTRAINTS
   1. X11+2X12+X13+2X14+X21+2X22+X23+2X24+X31+2X32+X33+2X34+X41+
      2X42+X43+2X44+X51+2X52.LE.1710000
   2. X15+X16+X25+X26+X35+X36+X45+X46.LE.285000
   3. X11+X12+X16.LE.20000
   4. X13+X14+X15.LE.506000
   5. X21+X22+X26=0
   6. X23+X24+X25.LE.105000
   7. X31+X32+X36.LE.50000
   8. X33+X34+X35.LE.50000
   9. X41+X42+X46=0
  10. X43+X44+X45.LE.79000
  11. X51+X52=0
  12. .04X23+.04X24-.96X25.LE.0
  13. .3X33+.3X34-.7X35.LE.0
  14. .04X43+.04X44-.96X45.LE.0
      OPTIMIZE
```

Resultater 4. periode

Results for period 4

VAR NO	VAR NAME	ROW NO	STATUS	ACTIVITY LEVEL	OPPORTUNITY COST	LOWER BOUND
1	X11	—	LB	0.0000000	.2900000	0.0000
2	X12	—	B	20000.0000000	0.0000000	0.0000
3	X13	—	LB	0.0000000	.2400000	0.0000
4	X14	—	B	506000.0000000	0.0000000	0.0000
5	X15	—	LB	0.0000000	.9500000	0.0000
6	X16	—	LB	0.0000000	1.9600000	0.0000
7	X21	—	LB	0.0000000	.2900000	0.0000
8	X22	—	B	0.0000000	0.0000000	0.0000
9	X23	—	LB	0.0000000	.2400000	0.0000
10	X24	—	B	100800.0000000	0.0000000	0.0000
11	X25	—	B	4200.0000000	0.0000000	0.0000
12	X26	—	LB	0.0000000	1.9600000	0.0000
13	X31	—	LB	0.0000000	.2900000	0.0000
14	X32	—	B	50000.0000000	0.0000000	0.0000
15	X33	—	LB	0.0000000	.2400000	0.0000
16	X34	—	B	35000.0000000	0.0000000	0.0000
17	X35	—	B	15000.0000000	0.0000000	0.0000
18	X36	—	LB	0.0000000	1.9600000	0.0000
19	X41	—	LB	0.0000000	.2900000	0.0000
20	X42	—	B	0.0000000	0.0000000	0.0000
21	X43	—	LB	0.0000000	.2400000	0.0000
22	X44	—	B	75840.0000000	0.0000000	0.0000
23	X45	—	B	3160.0000000	0.0000000	0.0000
24	X46	—	LB	0.0000000	1.2600000	0.0000
25	X51	—	LB	0.0000000	.2900000	0.0000
26	X52	—	B	0.0000000	0.0000000	0.0000
27	SLACK-- D-	1	B	134720.0000000	0.0000000	0.0000
28	SLACK-- D-	2	B	262640.0000000	0.0000000	0.0000
29	SLACK-- D-	3	LB	0.0000000	2.0500000	0.0000
30	SLACK-- D-	4	LB	0.0000000	3.8200000	0.0000
31	ARTIF-- D-	5	LB	0.0000000	2.1100000	0.0000
32	SLACK-- D-	6	LB	0.0000000	3.8420000	0.0000
33	SLACK-- D-	7	LB	0.0000000	2.8000000	0.0000
34	SLACK-- D-	8	LB	0.0000000	4.2850000	0.0000
35	ARTIF-- D-	9	LB	0.0000000	.9100000	0.0000
36	SLACK-- D-	10	LB	0.0000000	1.0332000	0.0000
37	ARTIF-- D-	11	LB	0.0000000	1.7500000	0.0000
38	SLACK-- D-	12	LB	0.0000000	.9500000	0.0000
39	SLACK-- D-	13	LB	0.0000000	.9500000	0.0000
40	SLACK-- D-	14	LB	0.0000000	1.1700000	0.0000

Maximum value of the objective function = 2813202.800000

6.3. Delivery times, fishing gear, fish species and use for the municipality of Sørøysund, 1978.

Quantity round weight (tonnes) by month and gear (1978) Sørøysund

Month	Gill-Net	LONG Line	HAND-long-line	Seine	Trawl	Danish seine	Other	Total kg
January	154	29	–	8	73	7	–	271
February	344	25	–	–	86	4	–	459
March	357	1	5	–	79	45	3	490
April	116	1	9	21	2	15	1	165
May	36	113	54	139	49	118	–	509
June	19	40	214	27	63	201	4	568
July	–	4	56	170	–	207	10	447
Aug.	23	21	129	455	–	394	5	1.027
Sept.	52	5	70	500	–	264	17	908
Oct.	57	3	24	361		100	2	547
Nov.	17	56	13	10	–	40	–	136
Dec.	5	28	1	4	–	44	–	82
Tot.	1 180	326	575	1.695	352	1.439	42	5.609
%	21,03	5,81	10,25	30,21	6,27	25,65	0,74	100%

Quantity round weight (tonnes) by fish species (1978) Sørøysund.

Month	Cod	Pollock	Haddock	Atlantic catfish	Greenland halibut	Cusk	Ling	Norway haddock	Other	Total kg
Jan.	214	4	43	–	–	1	–	2	5	269
Feb.	410	12	26	1	–	2	1	6	1	459
March	475	5	7	1	–	1	–	3	1	493
April	142	22	2	–	–	–	–	–	–	166
June	332	150	18	1	–	7	–	–	–	508
July	450	52	64	2	–	2	–	–	–	570
Aug.	193	239	17	–	–	–	–	–	1	450
Sept.	516	442	55	8	–	–	–	–	5	1.026
Oct.	287	551	45	2	–	1	1	5	14	905
Nov.	99	407	16	–	–	1	–	7	17	547
Dec.	61	23	27	–	–	7	–	–	18	136
	34	5	8	–	–	5	–	–	28	80
Tot.	3.213	1.912	328	15	–	27	1	23	90	5.609
%	57,28	34,08	5,84	0,26	–	0,48	0,01	0,04	1,60	100%

Quantity round weight (tonnes) by use (1978) Sørøsund

Month	Fresh	Frozen	Salted	Dried	Other	Total kg
Jan.	41	28	193	1	–	269
Feb.	17	49	385	8	–	459
March	5	64	409	14	–	493
April	3	22	84	57	–	166
May	70	284	122	32	–	508
June	76	417	29	47	–	570
July	30	415	–	3	–	448
August	136	834	33	19	–	1.026
September	145	643	113	5	–	906
October	77	211	226	33	–	547
November	77	23	18	18	–	136
December	50	13	17	1	–	81
Tot.	727	3.003	1.629	238	–	5.609
%	12,98	53,65	29,10	4,25	–	100%

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